DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
S. W. STRATTON, Director

PROGRESS REPORT
OF THE
NATIONAL SCREW THREAD COMMISSION

(AUTHORIZED BY CONGRESS, JULY 18, 1918, H. R. 10852)

AS APPROVED JUNE 19, 1920

JANUARY 4, 1921

MISCELLANEOUS PUBLICATIONS
OF THE
BUREAU OF STANDARDS

No. 42

WASHINGTON
GOVERNMENT PRINTING OFFICE
1921

NATIONAL SCREW THREAD COMMISSION,
WASHINGTON,

June 19, 1920.

The accompanying Progress Report of the National Screw Thread Commission has been approved by the Commission, and by the Secretaries of War, Navy, and Commerce, in accordance with the provisions of the law establishing the Commission.

APPROVAL BY THE MEMBERS OF THE COMMISSION.

The Progress Report of the National Screw Thread Commission, as revised in accordance with the vote of November 23–24, 1919, and embodying certain changes recommended by a special committee of the Society of Automotive Engineers, is hereby approved.

S. W. STRATTON,
Chairman.

E. C. PECK,
J. O. JOHNSON,
Representing the United States Army.

N. H. WRIGHT,
L. M. MCNAIR,
Representing the United States Navy.

JAMES HARTNESS,
F. O. WELLS,
Nominated by the American Society of Mechanical Engineers.

E. H. EHRMAN,
H. T. HERR,
Nominated by the Society of Automotive Engineers.

APPROVAL BY THE SECRETARIES OF WAR, NAVY, AND COMMERCE.

The attached report prepared by the National Screw Thread Commission, in accordance with the law establishing the Commission (Public doc. No. 201, 65th Cong., H. R. 10852), is hereby accepted and approved.

NEWTON D. BAKER,
Secretary of War.

JOSEPHUS DANIELS,
Secretary of the Navy.

JOSHUA W. ALEXANDER,
Secretary of Commerce.

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1921

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PREFACE

Recognizing the impossibility of bringing out a report of this character which in the first issue in entirely free from error or inconsistency, Congress has extended the life of the commission for a period of two years, in which such corrections and changes will be made as are found necessary or desirable by practical use of the report in the designing room and in the shop.

Criticisms and suggestions for the improvement of the report should be addressed to the National Screw Thread Commission, Bureau of Standards, Washington, D. C.

PROGRESS REPORT OF THE NATIONAL SCREW THREAD COMMISSION

(Authorized by Congress, July 18, 1918, H. R. 10852)

AS APPROVED JUNE 19, 1920

CONTENTS

I. INTRODUCTION

1. ORIGIN AND PROGRESS OF COMMISSION

The National Screw Thread Commission, which was created by an act of Congress (H. R. 10852) approved July 18, 1918, for the purpose of ascertaining and establishing standards for screw threads for use of the various branches of the Federal Government and for the use of manufacturers, recommends herewith certain systems of threads, together with information, data, and specifications pertaining to the manufacture of the threads recommended.

2. PURPOSE OF REPORT

It is the desire of the commission to make available to American manufacturers at the present time the information contained in its progress report for immediate use, rather than delay making a report in order to consider more fully the possibilities of international standardization of screw threads. It is the opinion of the commission, however, that international standardization of screw threads is very desirable and that the present time is most opportune for accomplishments in this direction. Further reference is made to the possibilities of international standardization in Section VIII of this report.

In the time provided in the act of Congress the commission has devoted its attention to the standardization of only those threads, sizes, types, and systems which are of paramount importance by reason of their extensive use and utility. As indicated in Section VIII, there remains much to be accomplished along the lines of standardization of special but important threads, and of maintaining progress in our standardization work in keeping with the developments of manufacturing conditions.

3. UTILITY OF REPORT

The advances made by the commission up to date will reduce the variety of screw threads in general use, facilitate manufacture in case of war, make the best use of labor in our industries in time of peace, increase the safety of travel by rail, steamship, and aeroplane, and in general will increase the dependability of all mechanisms. The war has given a new life to industrial activities in all countries and has made it necessary for us not only to share in the progress in standardization but to take advantage of every possible means to maintain America's progress. We, as a people, are keenly awake to the economic necessities of the reconstruction period and the period of peace following, and every step toward standardization of our products will result in increased production with a minimum expenditure of materials, energies, and other resources.

4. ORGANIZATION AND PROCEDURE OF COMMISSION

Prior to the formal appointment, under date of September 21, 1918, of the various commissioners, a preliminary meeting was held at Washington, D. C., on September 12. At this preliminary meeting was outlined the detailed organization of the commission as described in Appendix 2 and, also, a program covering the procedure of the commission as described in Appendix 3.

The commission in formulating this progress report has acted largely in the capacity of a judiciary, basing its decisions upon evidence received from authorities on screw-thread subjects and upon the conclusions drawn by other organizations having to do with standardization of screw threads. In addition, the various subjects dealt with have been considered with a knowledge of present manufacturing conditions and with anticipation of further development in the production of screw-thread products. Above all, it is the intention of the commission to facilitate and promote progress in manufacture.

5. ARRANGEMENT OF REPORT

There are included in the body of the report matters of particular importance and of general interest, while in the appendixes there is arranged detailed information of both a general and a technical nature. There is included in the body of the report sufficient information to permit the writing of definite and complete specifications for the purchase of screw-thread products, and there is included in the appendixes material which explains or goes more fully into the application of the specifications. The subjects covered in the report are arranged in the following manner:

II. TERMINOLOGY

1. INTRODUCTORY

In this progress report there are utilized, as far as possible, nontechnical words and terms which would best convey to the producer and user of screw threads the information presented.

2. DEFINITIONS

The following definitions are given of the more important terms used in the report. Definitions of terms which are obviously elementary in character are intentionally omitted.

(*a*) WORDS RELATING TO SCREW THREADS.—1. *Screw Thread.*—A ridge of uniform section wound in the form of a helix on the inside or outside surface of a cylinder or cone.

2. *Screw Helix.*—The path of a point moving at a uniform angular rate on a cylindrical or conical surface and at the same time moving at a uniform axial rate.

3. *Major Diameter (formerly known as "outside diameter").*—The largest diameter of the thread on the screw or nut. The term "major diameter" replaces the term "outside diameter" as applied to the thread of a screw and also the term "full diameter" as applied to the thread of a nut.

4. *Minor Diameter (formerly known as "core diameter").*—The smallest diameter of the thread on the screw or nut. The term "minor diameter" replaces the term "core diameter" as applied to the thread of a screw and also the term "inside diameter" as applied to the thread of a nut.

5. *Pitch Diameter.*—On a straight screw thread the diameter of an imaginary cylinder which would pass through the threads at

such points as to make the width of the threads and the width of the spaces cut by the surface of the cylinder equal

6. *Pitch.*—The distance from a point on a screw thread to a corresponding point on the next thread measured parallel to the axis.

$$\text{The pitch} = \frac{1}{\text{Number of threads per inch.}}$$

7. *Lead.*—The distance a screw thread advances axially in one turn. On a single-thread screw, the lead and pitch are identical; on a double-thread screw, the lead is twice the pitch; on a triple-thread screw, the lead is three times the pitch, etc.

8. *Angle of Thread.*—The angle included between the sides of the thread measured in an axial plane.

9. *Helix Angle.*—The angle made by the helix of the thread at the pitch diameter with a plane perpendicular to the axis.

10. *Crest.*—The top surface joining the two sides of a thread.

11. *Root.*—The bottom surface joining the sides of two adjacent threads.

12. *Side.*—The surface of the thread which connects the crest with the root.

13. *Axis of a Screw.*—The longitudinal central line through the screw.

14. *Base of Thread.*—The bottom section of the thread, the greatest section between the two adjacent roots.

15. *Depth of Thread.*—The distance between the top and the base of thread measured normal to the axis.

16. *Number of Threads.*—Number of threads in any unit of length.

17. *Length of Engagement.*—The length of contact between two mating parts, measured axially.

18. *Depth of Engagement.*—The depth of thread in contact of two mating parts, measured radially.

(*b*) Words Relating to Classification and Tolerances.—*1. Allowance* (*Neutral Zone*).—A difference in dimensions, the limits of which are prescribed; it is to provide for different kinds or classes of fit.

2. Tolerance.—A definite difference in the dimensions prescribed in order to permit of variations in manufacture.

Extreme Tolerance.—The maximum and minimum tolerance permitted by the designer, the limits of which are to be placed on the drawings. It is the net tolerance as affected by the master-gage tolerance.

Net Tolerance.—The tolerance limits within which the product is ordinarily passed by the master gages. It is the extreme tolerance as affected by the master-gage increment.

3. *Basic.*—The theoretical or nominal standard size from which all variations are made.

4. *Finish.*—The character of the surface on a screw thread.

5. *Crest Clearance.*—Defined on a screw form as the space between the top of a thread and the root of its mating thread.

6. *Fit.*—The relation between two mating parts with reference to ease of assembly; for example: Wrench fit; close fit; medium fit; loose fit. The quality of fit is dependent upon both the relative size and the quality of finish of the mating parts.

7. *Neutral Zone (Allowance).*—A space between the mating parts which must not be encroached upon.

8. *Gage Increment.*—Gage increment is a predetermined allowance by which the net tolerance of the product is increased for gaging purposes.

9. *Limits.*—The extreme dimensions, which are prescribed, to provide for variations in fit and workmanship.

3. SYMBOLS

For use in formulas for expressing relations of screw threads and for use on drawings and for similar purposes the following symbols should be used:

Major diameter	D
(Corresponding radius)	d
Pitch diameter	E
(Corresponding radius)	e
Minor diameter	K
(Corresponding radius)	k
Angle of thread	A
(One-half angle of thread)	a
Number of turns per inch	N
Number of threads per inch	n
Lead	$P = \frac{1}{N}$
Pitch or thread interval	$p = \frac{1}{n}$
Helix angle	s
Tangent of helix angle	$S = \frac{P}{3.14159 \times E}$
Width of basic flat at top, crest, or root	F
Depth of basic truncation	f
Depth of sharp V-thread	H
Depth of national (U. S.) form of thread	h
Included angle of taper	Y
(One-half included angle of taper)	y

Additional Symbols for national pipe threads are given in Sec. VII.

Symbols are for use on correspondence, drawings, shop and storeroom cards, specifications for parts, taps, dies, gages, etc., and on tools and gages.

The basis of the system is the initial letters of the series, preceded by the diameter in inches (or the screw number) and number of threads per inch, all in Arabic characters, followed by the classification of fit in Roman numerals. Examples:

	Mark
National Coarse-Thread System:	
To specify a threaded part 1 in.-diameter, 8 threads per inch, Class I fit.	1″—8—*NC*—I
National Fine-Thread System:	
Threaded part 1 in.-diameter, 14 threads per inch, Class III fit.	1″—14—*NF*—III
National Form, Special Pitch:	
Threaded part 1 in.-diameter, 12 threads per inch, Class IV fit.	1″—12—*N*—IV
National Pipe-Thread Series:	
National taper pipe thread. Threaded part 1 in.-diameter, 11½ threads per inch	1″—11½—*NPT*
National straight pipe thread	1″—11½—*NPS*
National Fire-Hose Thread Series and National Hose-Thread Series:	
Threaded part 3 in.-diameter, 6 threads per inch	3″—6—*NH*
Threaded part 1 in.-diameter, 11½ threads per inch	1″—11½—*NH*

REMARKS.—The number of threads per inch must be indicated in all cases, irrespective of whether it is the standard number of threads for that particular size of threaded part or special.

SYMBOLS FOR WIRE MEASUREMENTS

Measurement over wires	*M*
Diameter of wire	*G*
(Corresponding radius)	*g*

4. ILLUSTRATIONS SHOWING TERMINOLOGY

The following illustrations of thread forms illustrate the use of the terms used in the report and as previously defined. (See Figs. 1 and 2.)

III. FORM OF THREAD

1. NATIONAL FORM

The national form of thread profile as specified herein, and known previously as the United States Standard or Sellers' Profile, is adopted by the commission and shall hereafter be known as the National Form of Thread.

(*a*) WHERE USED.—The National Form of Thread Profile shall be used for all screw-thread work except when otherwise specified for special purposes.

(*b*) SPECIFICATIONS.—The basic angle of thread (*A*) between the sides of the thread measured in an axial plane shall be 60°. The line bisecting this 60° angle shall be perpendicular to the axis of the screw thread.

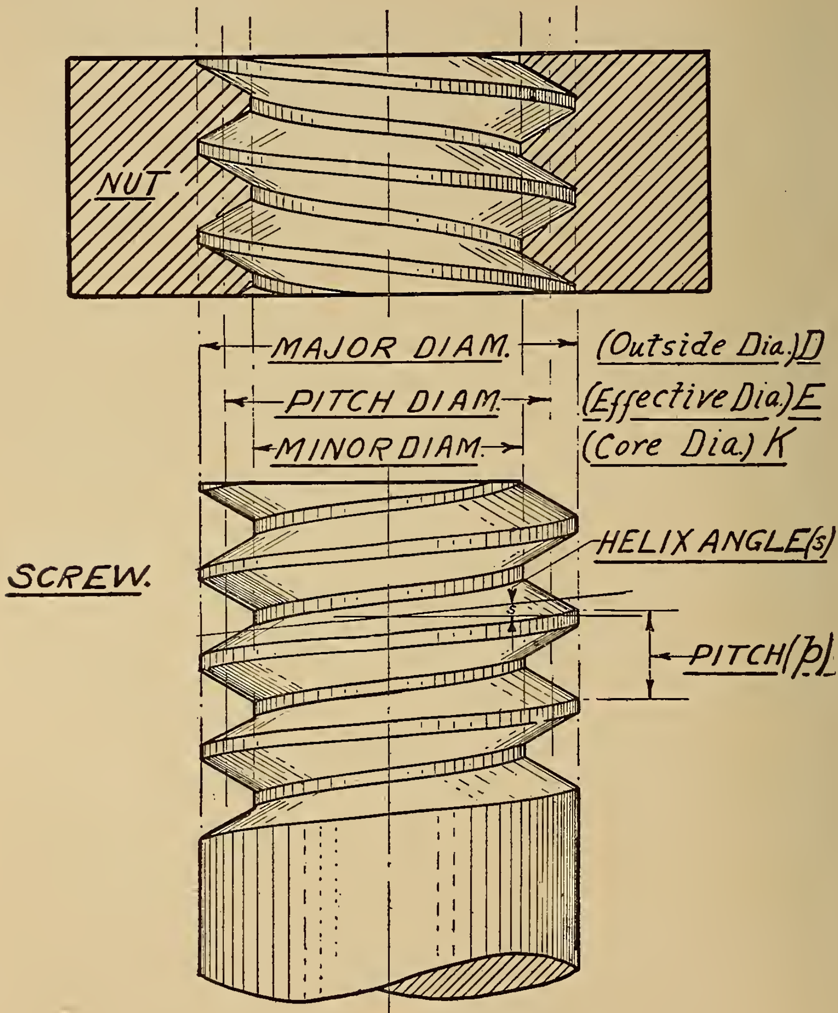


FIG. 1.—*Screw thread notation*

The basic flat at the root and crest of the thread form will be $\frac{1}{8} \times p$, or $0.125 \times p$.

The basic depth of the thread form will be $0.649519 \times p = \frac{0.649519}{n}$

where p = pitch in inches,

n = number of threads per inch.

(*c*) Illustration.—There are indicated in Fig. 3 the relations as specified herein for the National Form of Thread for the minimum nut and maximum screw, medium fit. These relations are further shown in Figs. 5, 9, and 11.

(*d*) Clearance in Nut.—1. *Clearance at Minor Diameter.*—A clearance shall be provided at the minor diameter of the nut by

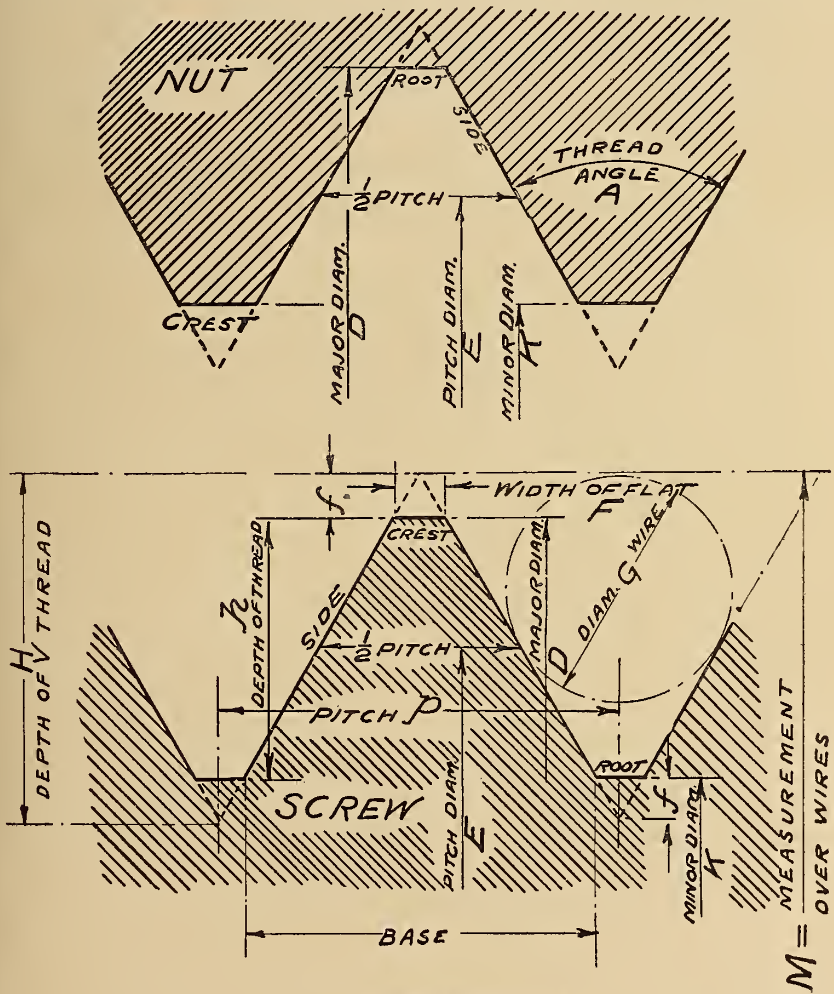
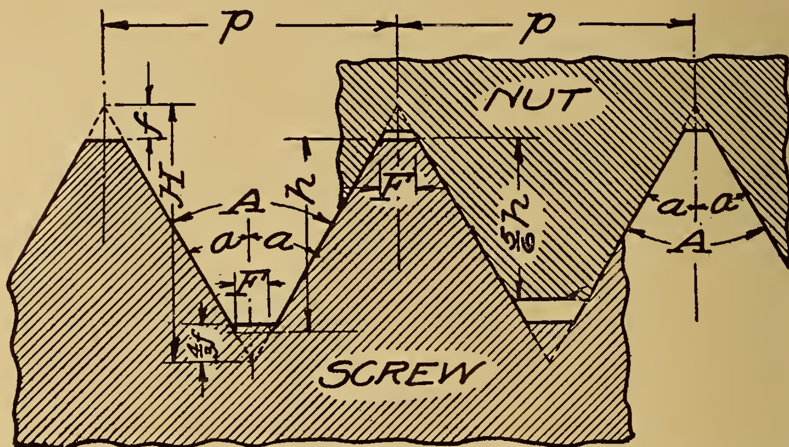


Fig. 2.—*Screw thread notation*

removing the thread form at the crest by an amount equal to one-sixth to one-fourth of the basic thread depth.

2. *Clearance at Major Diameter.*—A clearance at the major diameter of the nut shall be provided by decreasing the depth of the truncation triangle by an amount equal to one-third to two-thirds of its theoretical value.

National form of thread for minimum nut and maximum screw



NOTE.—No allowance is shown. This condition exists in Class II, Medium Fit, where both the minimum nut and the maximum screw are basic.

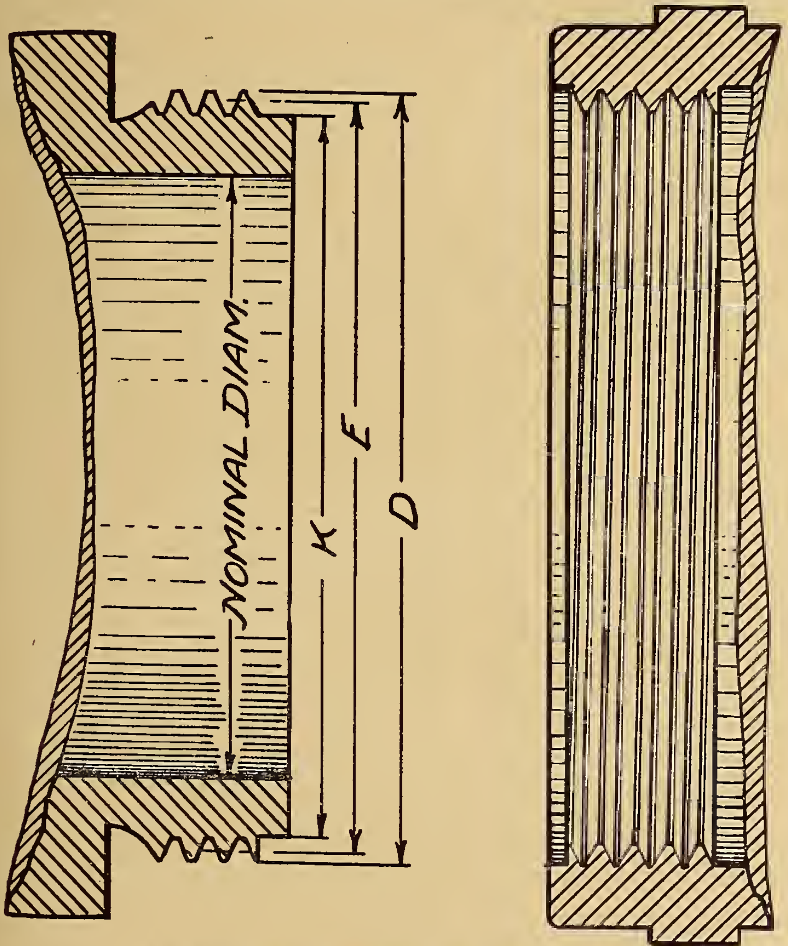
NOTATION

$A=60°$ . . . . Angle of thread
$a=30°$ . . . . One-half angle of thread
$p=\frac{l}{n}$ . . . . Pitch
$n=$ . . . .
$H=0.866025\ p$ . . Number of threads per inch
$h=\ .649519\ p$ . . Depth of 60° sharp V thread
$5/6h=\ .541266\ p$ . . Depth of national form thread
$F=\ .125000\ p$ . .
$f=\ .108253\ p$ . . Width of flat at crest and root of national form
$=1/8H$ . . . . . .
$=1/6h$ . . . . Depth of truncation

FIG. 3.—*National form of thread*

2. NATIONAL FIRE-HOSE COUPLING THREAD FORM

For threads cut on fire-hose couplings the form of the thread profile will be as specified herein and previously known and specified as the National Standard Hose Coupling Thread recommended



(See Tables 3 and 4 for dimensions. See Table 5 for tolerances)

FIG. 4.—*National fire hose and national hose coupling threads*

by the National Fire Protection Association and by the Bureau of Standards, and known hereafter as the National Fire-Hose Coupling Thread.

(*a*) SPECIFICATIONS.—The basic angle (A) between the sides of the thread measured in an axial plane shall be 60°. The line bisecting this 60° angle shall be perpendicular to the axis of the screw thread.

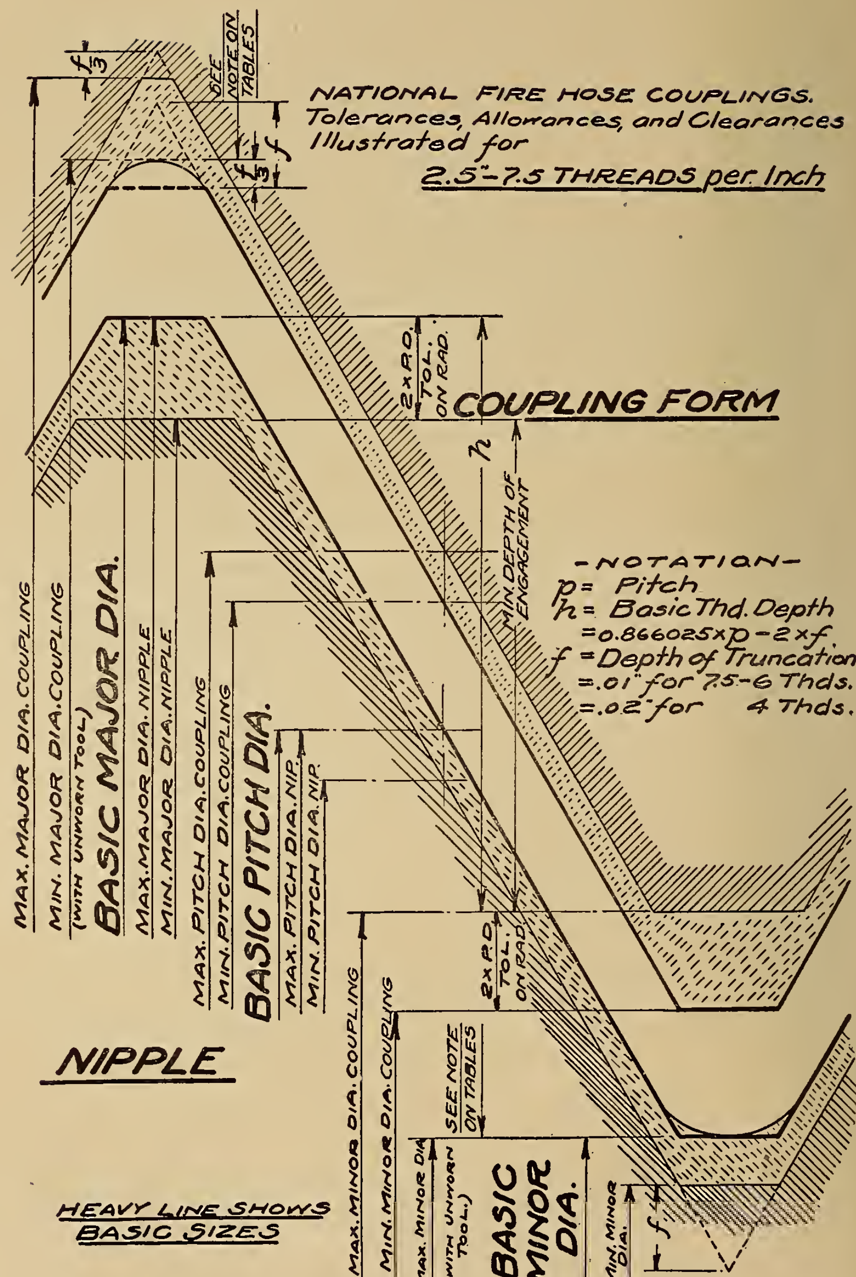


FIG. 5.—*National fire hose coupling thread*

National hose couplings tolerances, allowances, and clearances, illustrated for 3/4 in.—11 1/2 threads per inch

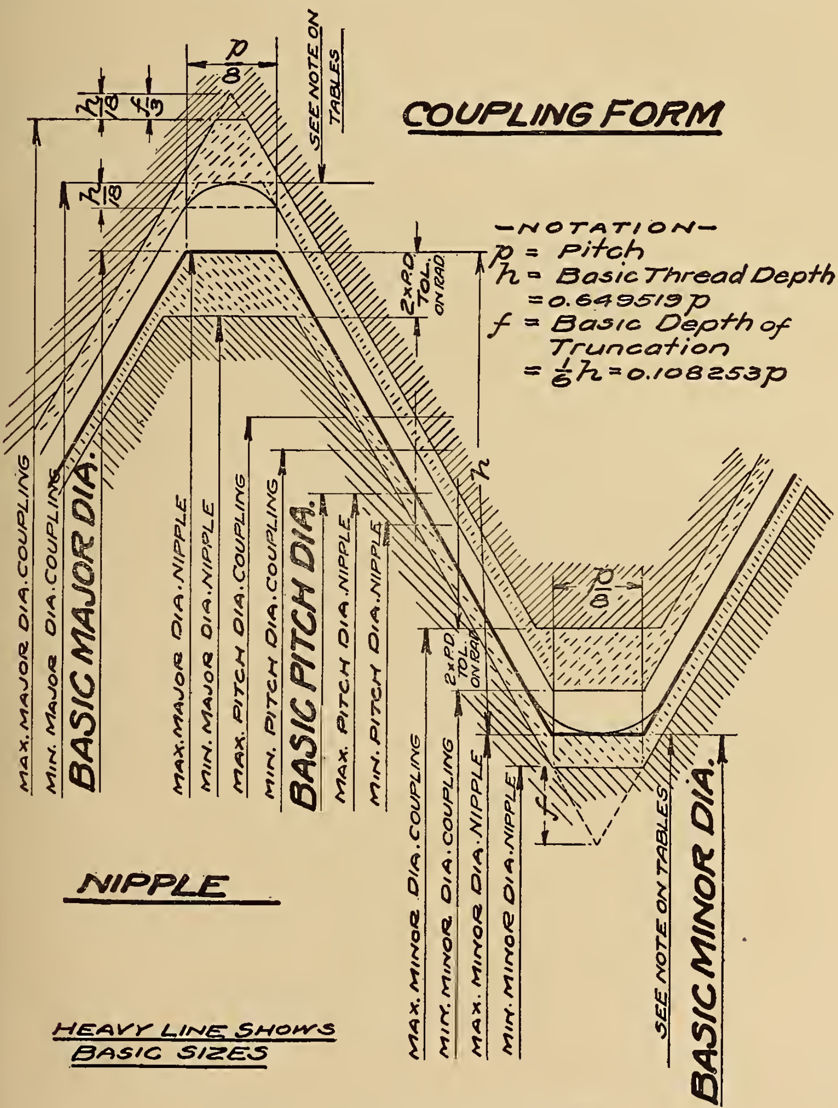


Fig. 6.—*National hose coupling thread*

The crest and root of the basic thread form will be flattened or truncated from a sharp V-form as follows:

Threads per inch:	Depth of truncation in inches
4	0.02
6	.01
7½	.01

3. NATIONAL HOSE-COUPLING THREAD FORM

For threads cut on hose couplings from ¾ inch to 2 inches, inclusive, the National Form of Thread shall be used as specified under Section III, "Form of Thread."

IV. THREAD SERIES ADOPTED

1. INTRODUCTORY

It is the aim of the commission, in establishing thread systems for adoption and general use, to eliminate all unnecessary sizes and in addition to utilize as far as possible present predominating sizes. While from certain standpoints it would have been desirable to make simplifications in the thread systems and to establish more thoroughly consistent standards, it is believed that any radical change at the present time would be out of place and interfere with manufacturing conditions, and would involve great economic loss.

The testimony given at the various hearings held by the commission is very consistent in favoring the maintenance of the present coarse-thread and fine-thread series, the coarse-thread series being the present "United States Standard" threads, supplemented in the sizes below one-fourth inch by the standard established by the American Society of Mechanical Engineers (A. S. M. E.). The fine-thread series is composed chiefly of standards that have been found necessary and consists of sizes taken from the standards of the Society of Automotive Engineers (S. A. E.), and the fine-thread series of the American Society of Mechanical Engineers (A. S. M. E.) The recommendation of these standards will tend toward their more universal use, and will constitute important gain that is affected by standardization with a minimum handicap.

Also, the testimony was very consistent in favoring the adoption in practically its present shape of the American Briggs standard pipe-thread sizes as recommended by the American Society of Mechanical Engineers and the fire-hose coupling sizes as established by the National Fire Protection Association.

2. NATIONAL COARSE-THREAD SERIES

There is specified in Table 1 a thread series which will be known as the National Coarse-Thread Series. This series contains certain sizes known previously as the United States Standard threads and also certain sizes known as the A. S. M. E. machine-screw threads. There are included in the National Coarse-Thread Series only those sizes which are essential.

(*a*) WHERE USED.—The National Coarse Threads are recommended for general use in engineering work, in machine construction where conditions are favorable to the use of bolts, screws, and other threaded components where quick and easy assembly of the parts is desired, and for all work where conditions do not require the use of fine-pitch threads.

(*b*) SPECIFICATIONS.—The series of sizes and basic dimensions are specified in Table 1.

1. *Form of Thread.*—The standard form of thread profile shall be used as specified and described in Section III, "Form of Thread."

2. *Classification and Tolerances.*—The National Coarse Thread shall be manufactured in accordance with the specifications as given in Section V, "Classification and Tolerances."

3. *Gages.*—The gages used for the manufacture of National Coarse Threads will be as specified in Section VI, "Gages."

3. NATIONAL FINE-THREAD SERIES

The threads specified in Table 2 will be known as the National Fine-Thread Series. This series contains certain sizes known previously as the S. A. E. threads, and, also, certain sizes known as the A. S. M. E. machine-screw sizes. There are included in the National Fine-Thread Series, only the sizes which are essential.

(*a*) WHERE USED.—The National Fine Threads are recommended for general use in automotive and aircraft work, for use where the design requires both strength and reduction in weight, and where special conditions require a fine thread, such as, for instance, on large sizes where sufficient force can not be secured to set properly a screw or bolt of coarse pitch, by exerting on an ordinary wrench the strength of a man.

(*b*) SPECIFICATIONS.—The series of sizes and basic dimensions are specified in Table 2.

1. *Form of Thread.*—The standard form of thread profile shall be used as specified and described in Section III, "Form of Thread."

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2. Classification and Tolerances.—The National Fine Thread shall be manufactured in accordance with specifications given in Section V, "Classification and Tolerances."

3. Gages.—The gages used for the manufacture of National Fine Threads will be as specified in Section VI, "Gages."

4. NATIONAL FIRE-HOSE COUPLING THREADS

There is specified in Table 3 a thread series and basic dimensions for fire-hose couplings from 2½ to 4½ in. diameter which will be known as the National Fire-Hose Threads. These basic sizes and dimensions correspond in all details to those recommended by the National Fire Protection Association and by the Bureau of Standards.

(*a*) WHERE USED.—The National Hose Thread shall be used on all couplings and hydrant connections for fire-protection systems and for all other purposes where hose couplings and connections are required in sizes between 2½ and 4½ in. in diameter.

(*b*) SPECIFICATIONS.—Series of sizes and basic dimensions for National Fire-Hose Threads are specified in Table 3.

1. Form of Thread.—There should be used a special form of thread as specified for National Fire-Hose Threads in Section III, "Form of Thread."

2. Classification and Tolerances.—National Fire-Hose Threads shall be manufactured in accordance with the specifications as given in Section V, "Classification and Tolerances."

3. Gages.—The gages used for the manufacture of National Fire-Hose Threads will be as specified in Section VI, "Gages."

5. NATIONAL HOSE-COUPLING THREADS

There is specified in Table 4 a thread series and basic dimensions for hose-coupling threads from ¾ to 2 in. in diameter, which will be known as the National Hose-Coupling Threads.

(*a*) WHERE USED.—The National Hose-Coupling Thread shall be used on all couplings and connections where sizes between ¾ and 2 in. in diameter are required.

(*b*) SPECIFICATIONS.—The series of sizes and basic dimensions for National Hose-Coupling Threads are specified in Table 4.

1. Form of Thread.—The National Form of Thread as specified in Section III, "Form of Thread," should be used.

2. Classification and Tolerances.—The National Hose-Coupling Thread shall be manufactured in accordance with the specifications as given in Section V, "Classification and Tolerances."

3. Gages.—The gages used for the manufacture of the National Hose-Coupling Thread will be as specified in Section VI, "Gages."

6. NATIONAL PIPE-THREAD SERIES

There are specified in Section VII, Tables 19, 20, and 21, thread series and basic dimensions for National Taper Pipe Threads, National Straight Pipe Threads, and National Locknut Threads.

TABLE 1.—National Coarse-Thread Series

Identification		Basic diameters			Thread data		
1	2	3	4	5	6	7	8
Sizes	*n* Threads per inch	*D* Major diam.	*E* Pitch diam.	*K* Minor diam.	Metric equivalent of major diam.	*p* Pitch	*h* Depth of thread
		Inches	Inches	Inches	mm	Inch	Inch
1	64	0.073	0.0629	0.0527	1.854	0.0156250	0.0101
2	56	.086	.0744	.0628	2.184	.0178571	.0116
3	48	.099	.0855	.0719	2.515	.0208333	.0135
4	40	.112	.0958	.0795	2.845	.0250000	.0162
5	40	.125	.1088	.0925	3.175	.0250000	.0162
6	32	.138	.1177	.0974	3.505	.0312500	.0203
8	32	.164	.1437	.1234	4.166	.0312500	.0203
10	24	.190	.1629	.1359	4.826	.0416667	.0271
12	24	.216	.1889	.1619	5.486	.0416667	.0271
¼	20	.2500	.2175	.1850	6.350	.0500000	.0325
5/16	18	.3125	.2764	.2403	7.938	.0555556	.0361
⅜	16	.3750	.3344	.2938	9.525	.0625000	.0406
7/16	14	.4375	.3911	.3447	11.113	.0714286	.0464
½	13	.5000	.4500	.4001	12.700	.0769231	.0500
9/16	12	.5625	.5084	.4542	14.288	.0833333	.0541
⅝	11	.6250	.5660	.5069	15.875	.0909091	.0590
¾	10	.7500	.6850	.6201	19.050	.1000000	.0650
⅞	9	.8750	.8028	.7307	22.225	.1111111	.0722
1	8	1.0000	.9188	.8376	25.400	.1250000	.0812
1⅛	7	1.1250	1.0322	.9394	28.575	.1428571	.0928
1¼	7	1.2500	1.1572	1.0644	31.750	.1428571	.0928
1½	6	1.5000	1.3917	1.2835	38.100	.1666667	.1083
1¾	5	1.7500	1.6201	1.4902	44.450	.2000000	.1299
2	4½	2.0000	1.8557	1.7113	50.800	.2222222	.1443
2¼	4½	2.2500	2.1057	1.9613	57.150	.2222222	.1443
2½	4	2.5000	2.3376	2.1752	63.500	.2500000	.1624
2¾	4	2.7500	2.5876	2.4252	69.850	.2500000	.1624
3	4	3.0000	2.8376	2.6752	76.200	.2500000	.1624

TABLE 2.—National Fine-Thread Series

Identification		Basic diameters			Thread data		
1	2	3	4	5	6	7	8
Sizes	*n* Threads per inch	*D* Major diam.	*E* Pitch diam.	*K* Minor diam.	Metric equivalent of major diam.	*p* Pitch	*h* Depth of thread
		Inches	Inches	Inches	mm	Inch	Inch
0	80	0.060	0.0519	0.0438	1.524	0.0125000	0.00812
1	72	.073	.0640	.0550	1.854	.0138889	.00902
2	64	.086	.0759	.0657	2.184	.0156250	.01014
3	56	.099	.0874	.0758	2.515	.0178571	.01160
4	48	.112	.0985	.0849	2.845	.0208333	.01353
5	44	.125	.1102	.0955	3.175	.0227273	.01476
6	40	.138	.1218	.1055	3.506	.0250000	.01624
8	36	.164	.1460	.1279	4.166	.0277778	.01804
10	32	.190	.1697	.1494	4.826	.0312500	.02030
12	28	.216	.1928	.1696	5.486	.0357143	.02319
1/4	28	.2500	.2268	.2036	6.350	.0357143	.02319
5/16	24	.3125	.2854	.2584	7.938	.0416667	.02706
3/8	24	.3750	.3479	.3209	9.525	.0416667	.02706
7/16	20	.4375	.4050	.3725	11.113	.0500000	.03248
1/2	20	.5000	.4675	.4350	12.700	.0500000	.03248
9/16	18	.5625	.5264	.4903	14.288	.0555556	.03608
5/8	18	.6250	.5889	.5528	15.875	.0555556	.03608
3/4	16	.7500	.7094	.6688	19.050	.0625000	.04060
7/8	14	.8750	.8286	.7822	22.225	.0714286	.04640
1	14	1.0000	.9536	.9072	25.400	.0714286	.04640
1 1/8	12	1.1250	1.0709	1.0167	28.575	.0833333	.05413
1 1/4	12	1.2500	1.1959	1.1417	31.750	.0833333	.05413
1 1/2	12	1.5000	1.4459	1.3917	38.100	.0833333	.05413
1 3/4	12	1.7500	1.6959	1.6417	44.450	.0833333	.05413
2	12	2.0000	1.9459	1.8917	50.800	.0833333	.05413
2 1/4	12	2.2500	2.1959	2.1417	57.150	.0833333	.05413
2 1/2	12	2.5000	2.4459	2.3917	63.500	.0833333	.05413
2 3/4	12	2.7500	2.6959	2.6417	69.850	.0833333	.05413
3	10	3.0000	2.9350	2.8701	76.200	.1000000	.06495

TABLE 3.—National Fire-Hose Couplings

BASIC MINIMUM COUPLING DIMENSIONS

Nominal size	Threads per inch	Pitch in inches	Depth of thread in inches	Major diameter in—		Pitch diameter in inches	Minor diameter in inches	Allowance, inches
				mm	Inches			
2.5000	7.5	0.13333	0.0955	78.550	3.0925	2.9970	2.9015	0.03
3.0000	6.0	.16667	.1243	92.837	3.6550	3.5306	3.4063	.03
3.5000	6.0	.16667	.1243	108.712	4.2800	4.1556	4.0313	.03
4.5000	4.0	.25000	.1765	147.320	5.8000	5.6235	5.4470	.05

BASIC MAXIMUM NIPPLE DIMENSIONS

2.5000	7.5	0.13333	0.0955	77.788	3.0625	2.9670	2.8715	0.03
3.0000	6.0	.16667	.1243	92.075	3.6250	3.5006	3.3763	.03
3.5000	6.0	.16667	.1243	107.950	4.2500	4.1256	4.0013	.03
4.5000	4.0	.25000	.1765	146.050	5.7500	5.5735	5.3970	.05

TABLE 4.—National Hose-Coupling Threads

BASIC MINIMUM COUPLING DIMENSIONS

Nominal size	Threads per inch	Pitch in inches	Depth of thread in inches	Major diameter in—		Pitch diameter in inches	Minor diameter in inches	Allowance, inches
				mm	Inches			
¾	11½	0.08696	0.0565	27.242	1.0725	1.0160	0.9595	0.01
1	11½	.08696	.0565	33.150	1.3051	1.2486	1.1922	.01
1¼	11½	.08696	.0565	41.908	1.6499	1.5934	1.5369	.01
1½	11½	.08696	.0565	47.976	1.8888	1.8323	1.7759	.01
2	11½	.08696	.0565	60.015	2.3628	2.3063	2.2498	.01

BASIC MAXIMUM NIPPLE DIMENSIONS

Nominal size	Threads per inch	Pitch in inches	Depth of thread in inches	Major diameter in mm	Major diameter in inches	Pitch diameter in inches	Minor diameter in inches	Allowance, inches
¾	11½	0.08696	0.0565	26.988	1.0625	1.0060	0.9495	0.01
1	11½	.08696	.0565	32.896	1.2951	1.2386	1.1822	.01
1¼	11½	.08696	.0565	41.654	1.6399	1.5834	1.5269	.01
1½	11½	.08696	.0565	47.722	1.8788	1.8223	1.7659	.01
2	11½	.08696	.0565	59.761	2.3528	2.2963	2.2398	.01

V. CLASSIFICATION AND TOLERANCES

1. GENERAL

One of the most important phases of standardization of screw-thread products is that of interchangeability. The direct result of establishing a national thread system will be the elimination of many unnecessary sizes. Of even more importance are the advantages to be gained in the manufacture of interchangeable screw-thread parts, which having been made in different manufacturing plants at widely separated points, will assemble without difficulty and in a manner which will insure proper operation of the mechanism being produced.

(*a*) STRICT INTERCHANGEABILITY.—Many manufacturers, previous to the war, were making interchangeable machine parts in their own shops where there was but one master gage or reference standard, but one individual who had authority to pass on parts in dispute, and where it was possible to secure assembly and satisfactory operation by fitting the parts.

The experience gained by manufacturers producing war material has demonstrated the economic advantage of producing interchangeable parts, especially where large quantities of parts are manufactured. In addition to the direct saving in the cost of manufacture, the numerous other advantages to be gained will make it mandatory that the procedure for producing interchangeable work as specified under the subject of classification and tolerances be explicitly followed, if we are to keep pace or lead in the world's progress as manufacturers.

(*b*) Need of Definite Specifications.—The difficulties encountered in obtaining enormous quantities of war material needed by the United States Government during the recent World War has pointed out to Government authorities, as well as manufacturers, the need of writing definite and complete specifications for material required. All specifications should be so written that the qualities in the product desired are stated in definite terms of known measurable standards and correctly defined by the largest tolerance limits compatible with the satisfactory operation or performance of the articles or material for the purpose intended. To this end every factor involved in the acceptability of the manufactured product required should be comparable within specified limits with a known measurable standard. Every specification should be so concise that no dispute regarding the limiting lines of acceptance can arise.

The specifications stated under classification and tolerances are intended for the sole purpose of establishing the physical dimensions of screw-thread products. While under tolerances various grades of workmanship are covered, it is not intended in any way to specify or limit the material or physical qualities required by the user. These specifications as to material and physical qualities must be established according to individual needs. Here again the importance of stating these requirements in concise and definite specifications is emphasized.

2. CLASSIFICATION OF FITS

There are established herein for general use, unless otherwise specified, four distinct classes of screw-thread fits with subdivisions as specified in the following brief outline of the four classes. These four classes of fits, together with the accompanying specifications, are for the purpose of insuring the interchangeable manufacture of screw-thread parts throughout the country.

The examples given under each class of fit are for the purpose of illustration only. It is not the intention of the commission to arbitrarily place a general class or grade of work in a specific class of fit. Each manufacturer and user of screw threads is free to select the class of fit best adapted to his particular needs. The tolerances and dimensions for each class of fit are given in Tables 5 to 18, inclusive.

Class I, loose fit		Includes screw-thread work of rough commercial quality, where the threads must assemble readily, and a certain amount of shake or play is not objectionable, such as artillery ammunition, hose couplings, etc.
Class II, medium fit.	Subdivision A (regular).	Includes the great bulk of screw-thread work of ordinary quality of finished and semifinished bolts and nuts, machine screws, etc.
	Subdivision B (special).	Includes the better grade of interchangeable screw-thread work, such as high grade automobile and aircraft bolts and nuts.
Class III, close fit		Includes screw-thread work requiring a fine snug fit, somewhat closer than the medium fit special. In this class of fit selective assembly of parts may be required.
Class IV, wrench fit.	Subdivision A	Includes screw threads used in light sections with moderate stresses, such as aircraft and automobile-engine work.
	Subdivision B	Includes screw threads used in heavy sections with heavy stresses, such as steam-engine and heavy hydraulic work.

On account of lack of data, tolerance and allowances are not specified herein for Class IV, Wrench Fit.

(*a*) General Specifications.—The following general specifications will apply to all classes of fits hereinafter specified.

1. *Uniform Minimum Nut.*—In order to conform to the general ideas of standardization the pitch diameter of the minimum-threaded hole or nut should correspond to the basic size, the errors due to workmanship being permitted above the basic size.

2. *Length of Engagement.*—The maximum length of engagement for screw threads manufactured in accordance with any of the classes of fit specified herein shall not exceed the quantity as determined in the following formula:

$$L = (1.5)\ D,$$

where L = length of engagement,
D = basic major diameter of thread.

3. *Scope of Classification.*—The specifications established for the various classes of fit are applicable to the National Coarse Threads, the National Fine Threads, the National Hose Threads, Straight Pipe Threads, and to any special thread required in manufacture which is not intentionally tapered.

(*b*) Class I, Loose Fit.—The loose-fit class of screw threads will be defined and specified as follows:

1. *Definition.*—This class is intended to cover the manufacture of strictly interchangeable threaded parts where the work is pro-

duced in two or more manufacturing plants. In this class will be included threads for artillery ammunition and rough commercial work, such as stove bolts, carriage bolts, and other threaded work of a similar nature, where quick and easy assembly is necessary and a certain amount of shake or play is not objectionable.

National Straight Pipe Threads and National Hose-Coupling Threads are to be produced in this class of fit only. National Fire-Hose Threads are to be produced in this class in accordance with special allowances and tolerances for fire-hose coupling threads, as given in Table 8.

2. *Minimum Nut Basic.*—The pitch diameter of the minimum nut of a given diameter and pitch will correspond to the basic pitch diameter as specified in the tables of thread systems given herein, which is computed from the basic major diameter of the thread to be manufactured. The pitch diameter of the minimum nut is the theoretical pitch diameter for that size.

3. *Maximum Screw Below Basic.*[1]—The dimensions of the maximum screw of a given pitch and diameter will be below the basic dimensions as specified in the tables of thread systems given herein, which are computed from the basic major diameter of the threads to be manufactured, by the amount of the allowance given in Table 5.

4. *Direction of Tolerance on Nut.*—The tolerance on the nut will be plus; to be applied from the basic size to above basic size.

5. *Direction of Tolerance on Screw.*—The tolerance on the screw will be minus; to be applied from the maximum screw dimension to below the maximum screw dimension.

6. *Allowance Values.*—The allowance provided between the size of the minimum nut, which is basic, and the size of the maximum screw for a screw thread of a given pitch, will be as specified in Table 5.

7. *Tolerance Values.*—The tolerance allowed on a screw or nut of a given pitch will be as specified in Table 5.

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[1] The maximum minor diameter of the screw is above the basic minor diameter, as shown in Fig. 7.

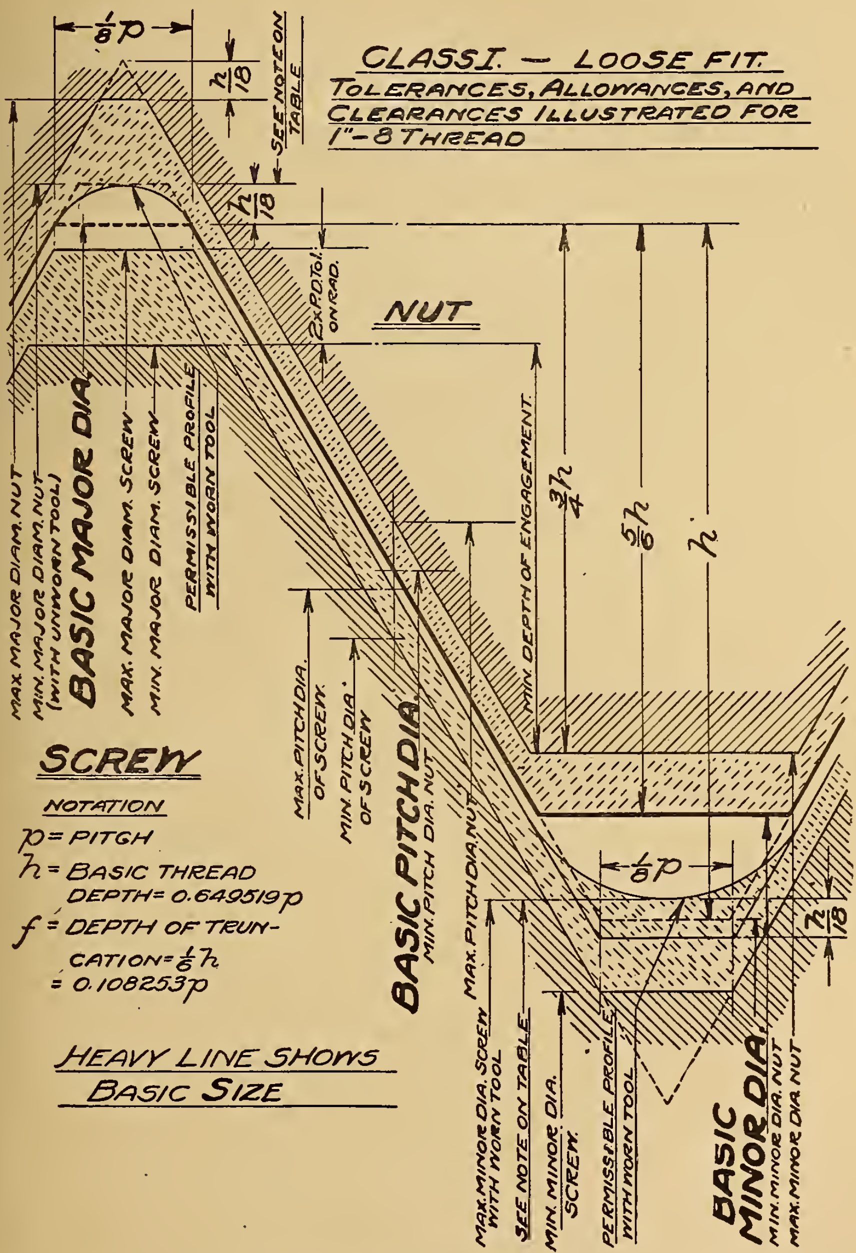


FIG. 7.—*Illustration of tolerance and allowance (neutral space) for Class I, loose fit*

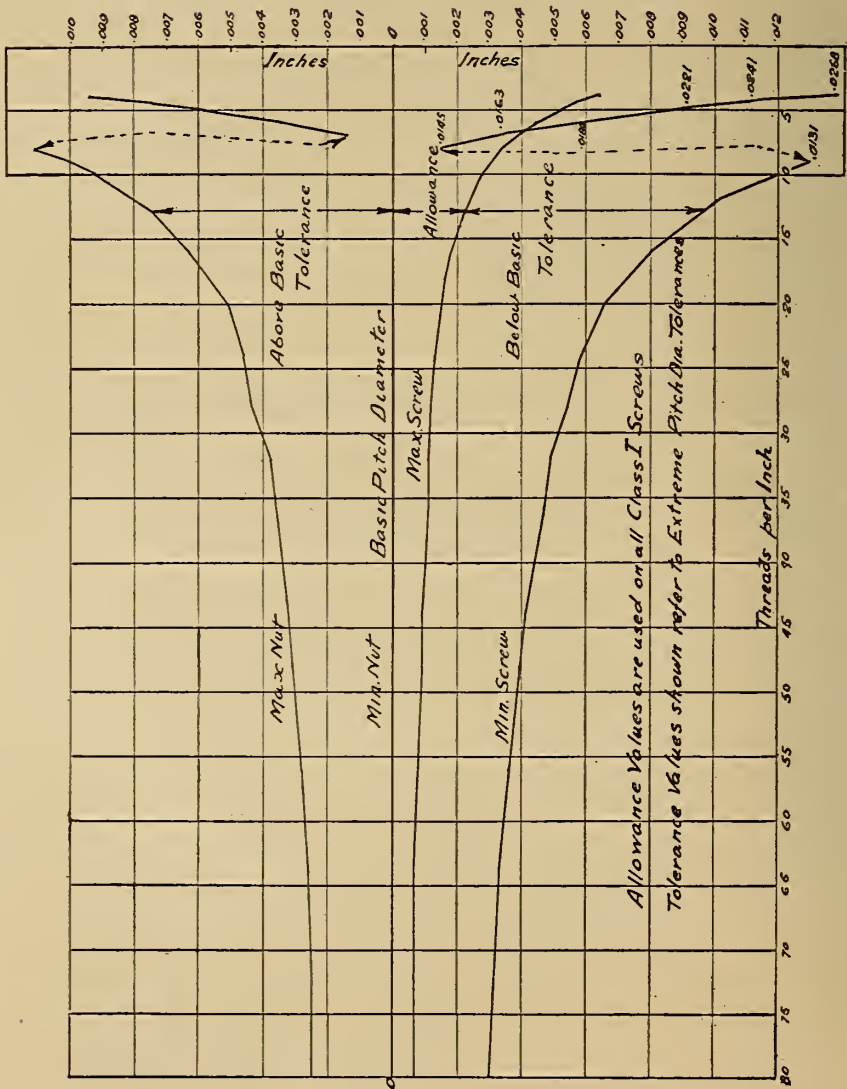
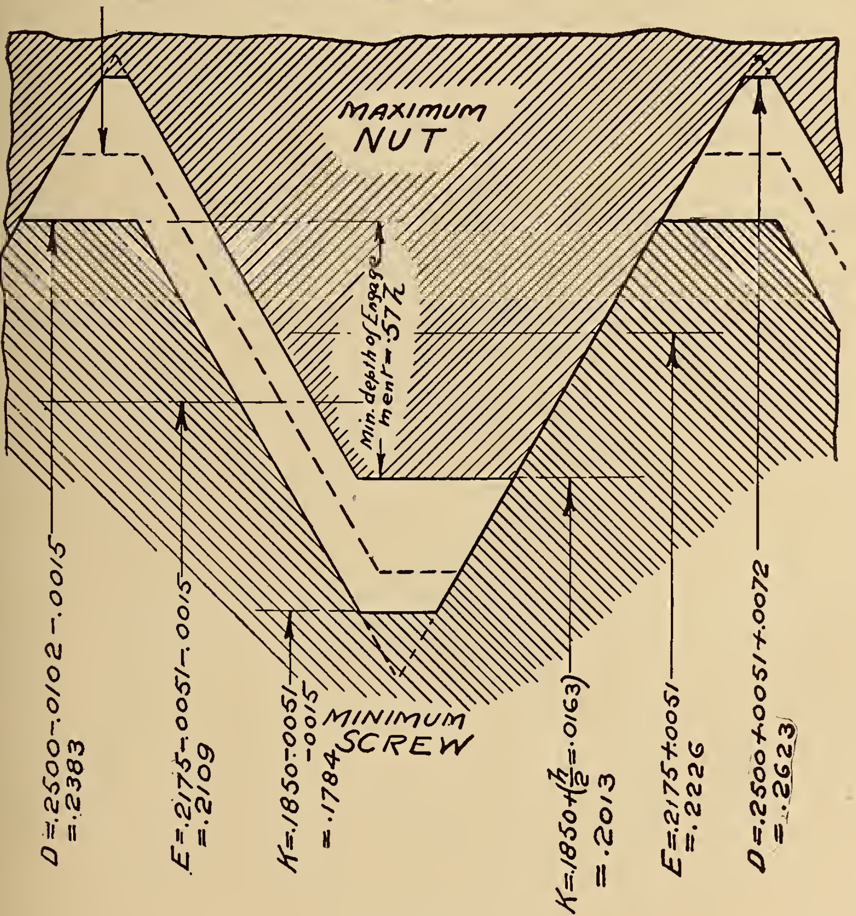


FIG. 8.—*Tolerance and allowance values for Class I, loose fit*

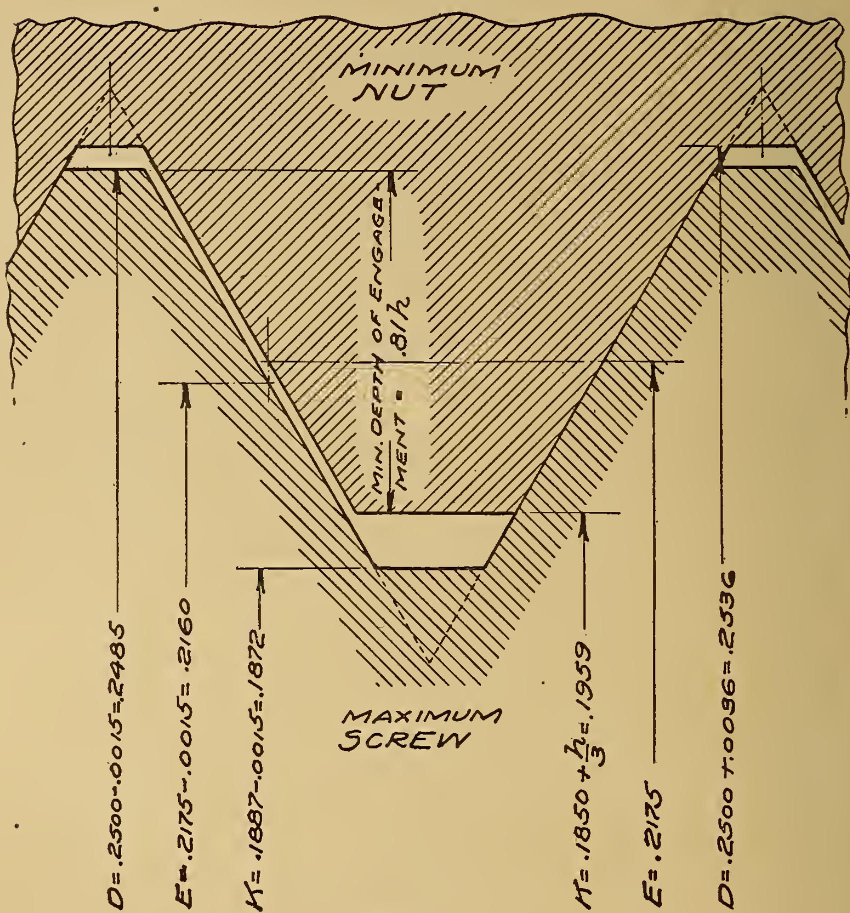
NOTE.—Dotted line shows basic size.



NOTATION

f=0.0054=Basic depth of truncation	D=Major diameter
h= .0325=Basic thread depth	E=Pitch diameter
	K=Minor diameter

FIG. 9.—*Illustration of loosest condition for Class I, loose fit, ¼ inch, 20 threads*



NOTATION

f=0.0054=Basic depth of truncation

h= .0325=Basic thread depth

D=Major diameter

E=Pitch diameter

K=Minor diameter

FIG. 10.—*Illustration of tightest condition for Class I, loose fit, ¼ inch, 20 threads*

TABLE 5.—Class I, Loose Fit, Allowances and Tolerances for Screws, Nuts, Gages, and Hose Couplings

1	2	3	4	5	6	7
Threads per inch	Allowances	Extreme or drawing pitch diameter tolerances	Master-gage tolerances [a]			Net pitch diameter tolerances
			Diameter	Lead [b]	½ angle	
	Inch	Inch	Inch	Inch	Deg. Min.	Inch
80	0.0007	0.0024	0.0002	±0.0002	±0 30	0.0020
72	.0007	.0025	.0002	± .0002	±0 30	.0021
64	.0007	.0026	.0002	± .0002	±0 30	.0022
56	.0008	.0028	.0002	± .0002	±0 30	.0024
48	.0009	.0031	.0002	± .0002	±0 30	.0027
44	.0009	.0032	.0002	± .0002	±0 30	.0028
40	.0010	.0034	.0002	± .0002	±0 20	.0030
36	.0011	.0036	.0002	± .0002	±0 20	.0032
32	.0011	.0038	.0002	± .0002	±0 20	.0034
28	.0012	.0043	.0003	± .0002	±0 15	.0037
24	.0013	.0046	.0003	± .0002	±0 15	.0040
20	.0015	.0051	.0003	± .0002	±0 15	.0045
18	.0016	.0057	.0004	± .0003	±0 10	.0049
16	.0018	.0063	.0004	± .0003	±0 10	.0055
14	.0021	.0070	.0004	± .0003	±0 10	.0062
13	.0022	.0074	.0004	± .0003	±0 10	.0066
12	.0024	.0079	.0004	± .0003	±0 10	.0071
11	.0026	.0085	.0004	± .0003	±0 10	.0077
10	.0028	.0092	.0004	± .0004	±0 5	.0084
9	.0031	.0100	.0004	± .0004	±0 5	.0092
8	.0034	.0111	.0004	± .0004	±0 5	.0103
7	.0039	.0124	.0004	± .0004	±0 5	.0116
6	.0044	.0145	.0006	± .0005	±0 5	.0133
5	.0052	.0169	.0006	± .0005	±0 5	.0157
4½	.0057	.0184	.0006	± .0005	±0 5	.0172
4	.0064	.0204	.0006	± .0005	±0 5	.0192

[a] See "VI. Gages."
[b] Allowable variation in lead between any two threads not farther apart than the length of engagement.

TABLE 6.—Class I, Loose Fit, National Coarse-Thread Series

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sizes	Threads per inch	Screw sizes						Nut sizes						Basic major diameter
		Major diameter		Pitch diameter		Minor diameter		Minor diameter		Pitch diameter		Major diameter		
		Max.	Min.	Max.	Min.	Max.[a]	Min.	Min.	Max.	Min.	Max.	Min.[a]	Max.	
		Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1	64	0.0723	0.0671	0.0622	0.0596	0.0531	0.0494	0.0561	0.0578	0.0629	0.0655	0.0741	0.0779	0.073
2	56	.0852	.0796	.0736	.0708	.0633	.0592	.0667	.0686	.0744	.0772	.0873	.0914	.608
3	48	.0981	.0919	.0846	.0815	.0725	.0679	.0764	.0787	.0855	.0886	.1005	.1051	.099
4	40	.1110	.1042	.0948	.0914	.0803	.0751	.0849	.0876	.0958	.0992	.1138	.1190	.112
5	40	.1240	.1172	.1078	.1044	.0933	.0881	.0979	.1006	.1088	.1122	.1268	.1320	.125
6	32	.1369	.1293	.1166	.1128	.0986	.0925	.1042	.1076	.1177	.1215	.1403	.1463	.138
8	32	.1629	.1553	.1426	.1388	.1246	.1185	.1302	.1336	.1437	.1475	.1663	.1723	.164
10	24	.1887	.1795	.1616	.1570	.1376	.1300	.1449	.1494	.1629	.1675	.1930	.2006	.190
12	24	.2147	.2055	.1876	.1830	.1636	.1560	.1709	.1754	.1889	.1935	.2190	.2266	.216
1/4	20	.2485	.2383	.2160	.2109	.1872	.1784	.1959	.2013	.2175	.2226	.2536	.2623	.2500
5/16	18	.3109	.2995	.2748	.2691	.2427	.2330	.2524	.2584	.2764	.2821	.3165	.3262	.3125
3/8	16	.3732	.3606	.3326	.3263	.2965	.2857	.3073	.3141	.3344	.3407	.3795	.3903	.3750
7/16	14	.4354	.4214	.3890	.3820	.3478	.3356	.3602	.3679	.3911	.3981	.4427	.4548	.4375
1/2	13	.4978	.4830	.4478	.4404	.4034	.3905	.4167	.4251	.4500	.4574	.5056	.5185	.5000
9/16	12	.5601	.5443	.5060	.4981	.4579	.4439	.4723	.4813	.5084	.5163	.5685	.5824	.5625
5/8	11	.6224	.6054	.5634	.5549	.5109	.4958	.5266	.5364	.5660	.5745	.6316	.6466	.6250
3/4	10	.7472	.7288	.6822	.6730	.6245	.6081	.6417	.6526	.6850	.6942	.7572	.7736	.7500
7/8	9	.8719	.8519	.7997	.7897	.7356	.7176	.7547	.7667	.8028	.8128	.8830	.9010	.8750
1	8	.9966	.9744	.9154	.9043	.8432	.8231	.8647	.8782	.9188	.9299	1.0090	1.0291	1.0000
1 1/8	7	1.1211	1.0963	1.0283	1.0159	.9458	.9231	.9704	.9858	1.0322	1.0446	1.1353	1.1580	1.1250
1 1/4	7	1.2461	1.2213	1.1533	1.1409	1.0708	1.0481	1.0954	1.1108	1.1572	1.1696	1.2603	1.2830	1.2500
1 1/2	6	1.4956	1.4666	1.3873	1.3728	1.2911	1.2646	1.3196	1.3376	1.3917	1.4062	1.5120	1.5386	1.5000
1 3/4	5	1.7448	1.7110	1.6149	1.5980	1.4994	1.4681	1.5335	1.5551	1.6201	1.6370	1.7644	1.7958	1.7500
2	4 1/2	1.9943	1.9575	1.8500	1.8316	1.7217	1.6872	1.7594	1.7835	1.8557	1.8741	2.0160	2.0505	2.0000
2 1/4	4 1/2	2.2443	2.2075	2.1000	2.0816	1.9717	1.9372	2.0094	2.0335	2.1057	2.1241	2.2660	2.3005	2.2500
2 1/2	4	2.4936	2.4528	2.3312	2.3108	2.1869	2.1484	2.2294	2.2564	2.3376	2.3580	2.5180	2.5565	2.5000
2 3/4	4	2.7436	2.7028	2.5812	2.5608	2.4369	2.3984	2.4794	2.5064	2.5876	2.6080	2.7680	2.8065	2.7500
3	4	2.9936	2.9528	2.8312	2.8108	2.6869	2.6484	2.7294	2.7564	2.8376	2.8580	3.0180	3.0565	3.0000

[a] Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root. The dimensions given in the tables of screw and nut sizes are the limiting dimensions of the work and not of the gages.

TABLE 7.—Class I, Loose Fit, National Fine-Thread Series

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sizes	Threads per inch	Screw sizes						Nut sizes						Basic major diameter
		Major diameter		Pitch diameter		Minor diameter		Minor diameter		Pitch diameter		Major diameter		
		Max.	Min.	Max.	Min.	Max.[a]	Min.	Min.	Max.	Min.	Max.	Min.[a]	Max.	
		Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
0	80	0.0593	0.0545	0.0512	0.0488	0.0440	0.0407	0.0465	0.0478	0.0519	0.0543	0.0609	0.0642	0.060
1	72	.0723	.0673	.0633	.0608	.0553	.0518	.0580	.0595	.0640	.0665	.0740	.0775	.073
2	64	.0853	.0801	.0752	.0726	.0661	.0624	.0691	.0708	.0759	.0785	.0871	.0909	.086
3	56	.0982	.0926	.0866	.0838	.0763	.0722	.0797	.0816	.0874	.0902	.1003	.1044	.099
4	48	.1111	.1049	.0976	.0945	.0855	.0809	.0894	.0917	.0985	.1016	.1135	.1181	.112
5	44	.1241	.1177	.1093	.1061	.0962	.0914	.1004	.1029	.1102	.1134	.1266	.1315	.125
6	40	.1370	.1302	.1208	.1174	.1063	.1011	.1109	.1136	.1218	.1252	.1398	.1450	.138
8	36	.1629	.1557	.1449	.1413	.1288	.1232	.1339	.1369	.1460	.1496	.1660	.1716	.164
10	32	.1889	.1813	.1686	.1648	.1506	.1445	.1562	.1596	.1697	.1735	.1923	.1983	.190
12	28	.2148	.2062	.1916	.1873	.1710	.1641	.1773	.1812	.1928	.1971	.2186	.2255	.216
1/4	28	.2488	.2402	.2256	.2213	.2050	.1981	.2113	.2152	.2268	.2311	.2526	.2595	.2500
5/16	24	.3112	.3020	.2841	.2795	.2601	.2525	.2674	.2719	.2854	.2900	.3155	.3231	.3125
3/8	24	.3737	.3645	.3466	.3420	.3226	.3150	.3299	.3344	.3479	.3525	.3780	.3856	.3750
7/16	20	.4360	.4258	.4035	.3984	.3747	.3659	.3834	.3888	.4050	.4101	.4411	.4498	.4375
1/2	20	.4985	.4883	.4660	.4609	.4372	.4284	.4459	.4513	.4675	.4726	.5036	.5123	.5000
9/16	18	.5609	.5495	.5248	.5191	.4927	.4830	.5024	.5084	.5264	.5321	.5665	.5762	.5625
5/8	18	.6234	.6120	.5873	.5816	.5552	.5455	.5649	.5709	.5889	.5946	.6290	.6387	.6250
3/4	16	.7482	.7356	.7076	.7013	.6715	.6607	.6823	.6891	.7094	.7157	.7545	.7653	.7500
7/8	14	.8729	.8589	.8265	.8195	.7853	.7731	.7977	.8054	.8286	.8356	.8802	.8923	.8750
1	14	.9979	.9839	.9515	.9445	.9103	.8981	.9227	.9304	.9536	.9606	1.0052	1.0173	1.0000
1 1/8	12	1.1226	1.1068	1.0685	1.0606	1.0204	1.0064	1.0348	1.0438	1.0709	1.0788	1.1310	1.1449	1.1250
1 1/4	12	1.2476	1.2318	1.1935	1.1856	1.1454	1.1314	1.1598	1.1688	1.1959	1.2038	1.2560	1.2699	1.2500
1 1/2	12	1.4976	1.4818	1.4435	1.4356	1.3954	1.3814	1.4098	1.4188	1.4459	1.4538	1.5060	1.5199	1.5000
1 3/4	12	1. 476	1.7318	1.6935	1.6856	1.6454	1.6314	1.6598	1.6688	1.6959	1.7038	1.7560	1.7699	1.7500
2	12	1.9976	1.9818	1.9435	1.9356	1.8954	1.8814	1.9098	1.9188	1.9459	1.9538	2.0060	2.0199	2.0000
2 1/4	12	2.2476	2.2318	2.1935	2.1856	2.1454	2.1314	2.1598	2.1688	2.1959	2.2038	2.2560	2.2699	2.2500
2 1/2	12	2.4976	2.4818	2.4435	2.4356	2.3954	2.3814	2.4098	2.4188	2.4459	2.4538	2.5060	2.5199	2.5000
2 3/4	12	2.7476	2.7318	2.6935	2.6856	2.6454	2.6314	2.6598	2.6688	2.6959	2.7038	2.7560	2.7699	2.7500
3	10	2.9972	2.9788	2.9322	2.9230	2.8745	2.8581	2.8917	2.9026	2.9350	2.9442	3.0072	3.0236	3.0000

[a] Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root. The dimensions given in the tables of screw and nut sizes are the limiting dimensions of the work and not of the gages.

TABLE 8.—National Fire-Hose Couplings, Thread Dimensions

COUPLING THREAD

Nominal size	Threads per inch	Pitch	Depth of thread	Major diameter		Pitch diameter		Minor diameter	
				Max.	Min.	Max.	Min.	Max.	Min.
		Inch	Inch	Inches	Inches	Inches	Inches	Inches	Inches
2.5000.....	7.5	0.13333	0.09547	3.1183	[a] 3.0992	3.0094	2.9970	2.9263	2.9015
3.0000.....	6.0	.16667	.12434	3.6829	[a] 3.6617	3.5451	3.5306	3.4353	3.4063
3.5000.....	6.0	.16667	.12434	4.3079	[a] 4.2867	4.1701	4.1556	4.0603	4.0313
4.5000.....	4.0	.25000	.17651	5.8470	[a] 5.8133	5.6439	5.6235	5.4878	5.4470

NIPPLE THREAD

Nominal size	Threads per inch	Pitch	Depth of thread	Major diameter Max.	Major diameter Min.	Pitch diameter Max.	Pitch diameter Min.	Minor diameter Max.	Minor diameter Min.
2.5000.....	7.5	0.13333	0.09547	3.0625	3.0377	2.9670	2.9546	[a] 2.8715	2.8591
3.0000.....	6.0	.16667	.12434	3.6250	3.5960	3.5006	3.4861	[a] 3.3763	3.3618
3.5000.....	6.0	.16667	.12434	4.2500	4.2210	4.1256	4.1111	[a] 4.0013	3.9868
4.5000.....	4.0	.25000	.17651	5.7500	5.7092	5.5735	5.5531	[a] 5.3970	5.3763

[a] Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root. The dimensions given in the tables of coupling and nipple sizes are the limiting dimensions of the work and not of the gages.

TABLE 9.—National Hose Couplings, Thread Dimensions

COUPLING THREAD

Nominal size	Threads per inch	Pitch	Depth of thread	Major diameter		Pitch diameter		Minor diameter	
				Max.	Min.	Max.	Min.	Max.	Min.
		Inch	Inch	Inches	Inches	Inches	Inches	Inches	Inches
¾.........	11½	0.08696	0.05648	1.0936	[a] 1.0788	1.0245	1.0160	0.9765	0.9595
1..........	11½	.08696	.05648	1.3262	[a] 1.3114	1.2571	1.2486	1.2091	1.1921
1¼.........	11½	.08696	.05648	1.6710	[a] 1.6562	1.6019	1.5934	1.5539	1.5369
1½.........	11½	.08696	.05648	1.9099	[a] 1.8951	1.8408	1.8323	1.7929	1.7759
2..........	11½	.08696	.05648	2.3839	[a] 2.3691	2.3148	2.3063	2.2668	2.2498

NIPPLE THREAD

Nominal size	Threads per inch	Pitch	Depth of thread	Major diameter Max.	Major diameter Min.	Pitch diameter Max.	Pitch diameter Min.	Minor diameter Max.	Minor diameter Min.
¾.........	11½	0.08696	0.05648	1.0625	1.0455	1.0060	0.9975	[a] 0.9495	0.9410
1..........	11½	.08696	.05648	1.2951	1.2781	1.2386	1.2301	[a] 1.1821	1.1736
1¼.........	11½	.08696	.05648	1.6399	1.6229	1.5834	1.5749	[a] 1.5269	1.5184
1½.........	11½	.08696	.05648	1.8788	1.8618	1.8223	1.8138	[a] 1.7659	1.7574
2..........	11½	.08696	.05648	2.3528	2.3358	2.2963	2.2878	[a] 2.2398	2.2313

[a] Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root. The dimensions given in the tables of coupling and nipple sizes are the limiting dimensions of the work and not of the gages.

(*c*) Class II–A, Medium Fit (Regular).—This class of screw threads will be defined and specified as follows:

1. Definition.—The medium-fit class, Subdivision A, Regular, is intended to apply to interchangeable manufacture where the threaded members are to assemble nearly, or entirely, with the fingers and where a moderate amount of shake or play between the assembled threaded members is not objectionable. This class will include the great bulk of fastening screws for instruments, small arms, and other ordnance material, such as gun carriages, aerial bomb-dropping devices, and interchangeable accessories mounted on guns; also machine screws, cap screws, and screws for sewing machines, typewriters, and other work of a similar nature.

2. Minimum Nut Basic.—The pitch diameter of the minimum nut of a given diameter and pitch will correspond to the basic pitch diameter as specified in tables of thread systems given herein which is computed from the basic major diameter of the thread to be manufactured.

3. Maximum Screw Basic.—The major diameter and pitch diameter of the maximum screw of a given pitch and diameter will correspond to the basic dimensions as specified in tables of thread systems given herein which are computed from the basic major diameter of the thread to be manufactured.

4. Direction of Tolerance on Nut.—The tolerance on the nut will be plus; to be applied from the basic size to above basic size.

5. Direction of Tolerance on Screw.[2]—The tolerance on the screw will be minus; to be applied from the maximum size to below maximum size.

6. Zero Allowance.—The allowance between the pitch diameter of the maximum screw and the minimum nut will be zero for all pitches and all diameters.

7. Tolerance Values.—The tolerance for a screw or nut of a given pitch will be as specified in Table 10.

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[2] The maximum minor diameter of the screw is above the basic minor diameter, as shown in Fig. 11.

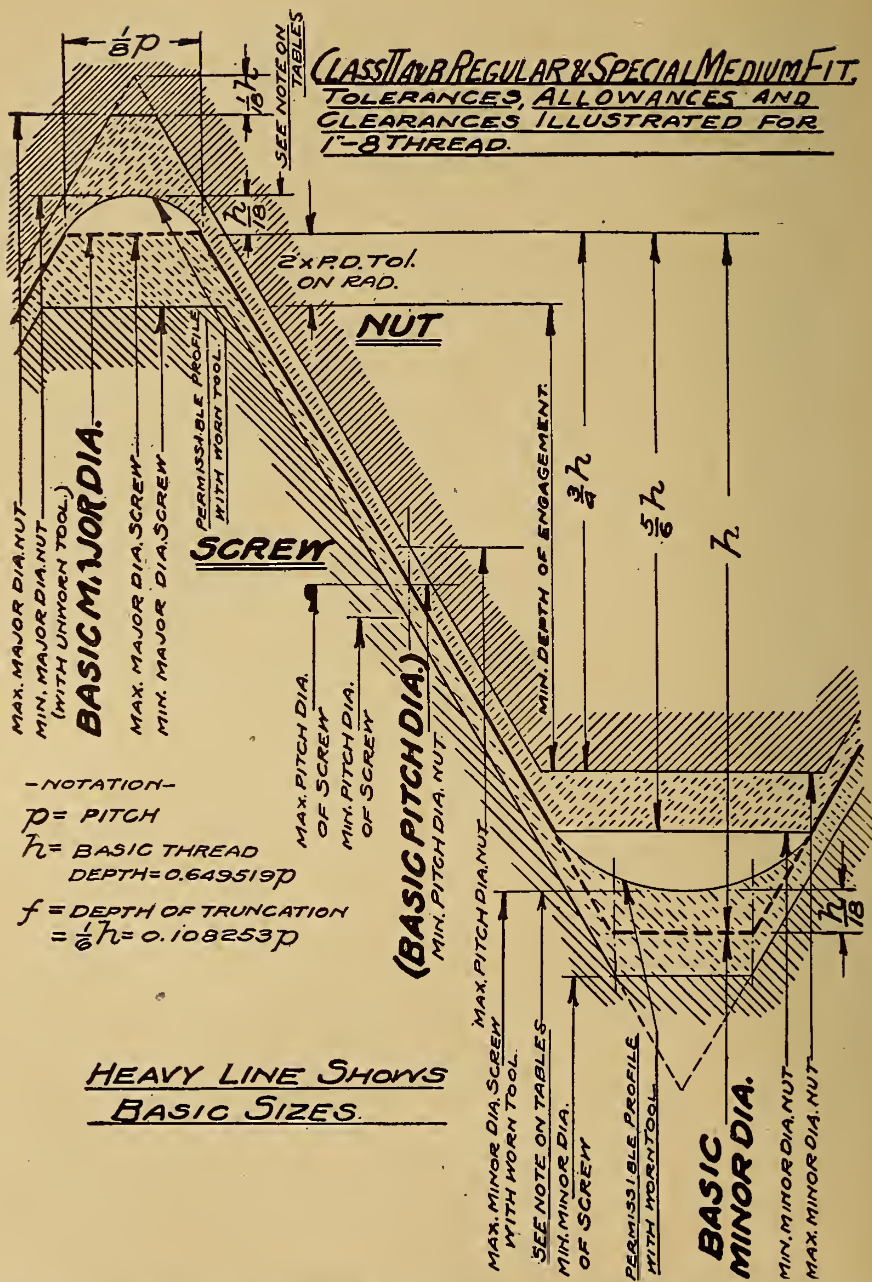


FIG. 11.—*Illustration of tolerance and allowance for Classes II–A and II–B, medium fit*

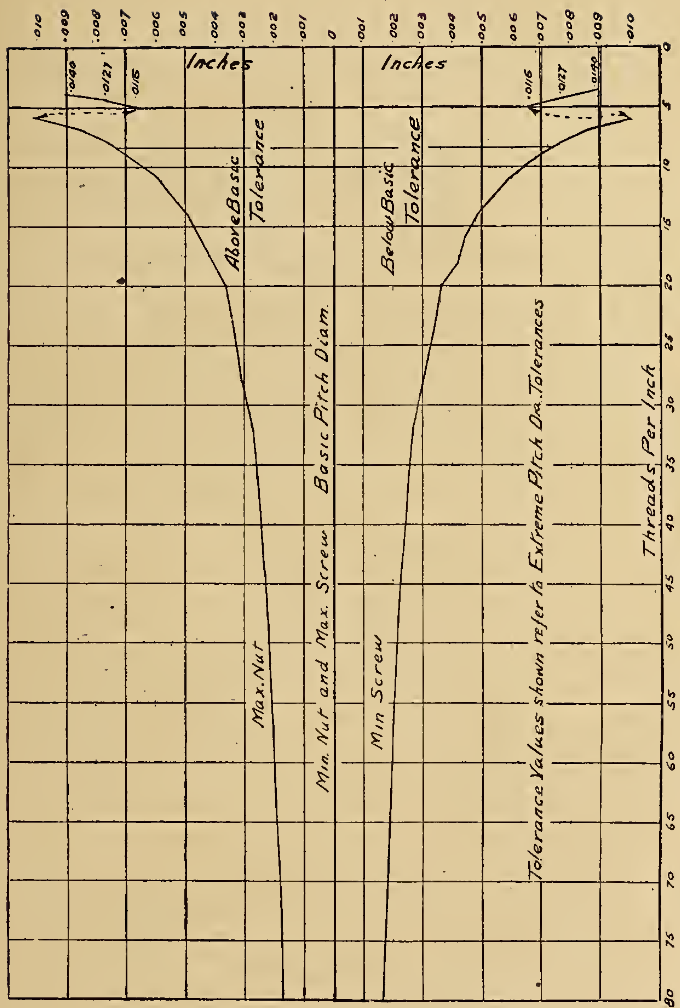
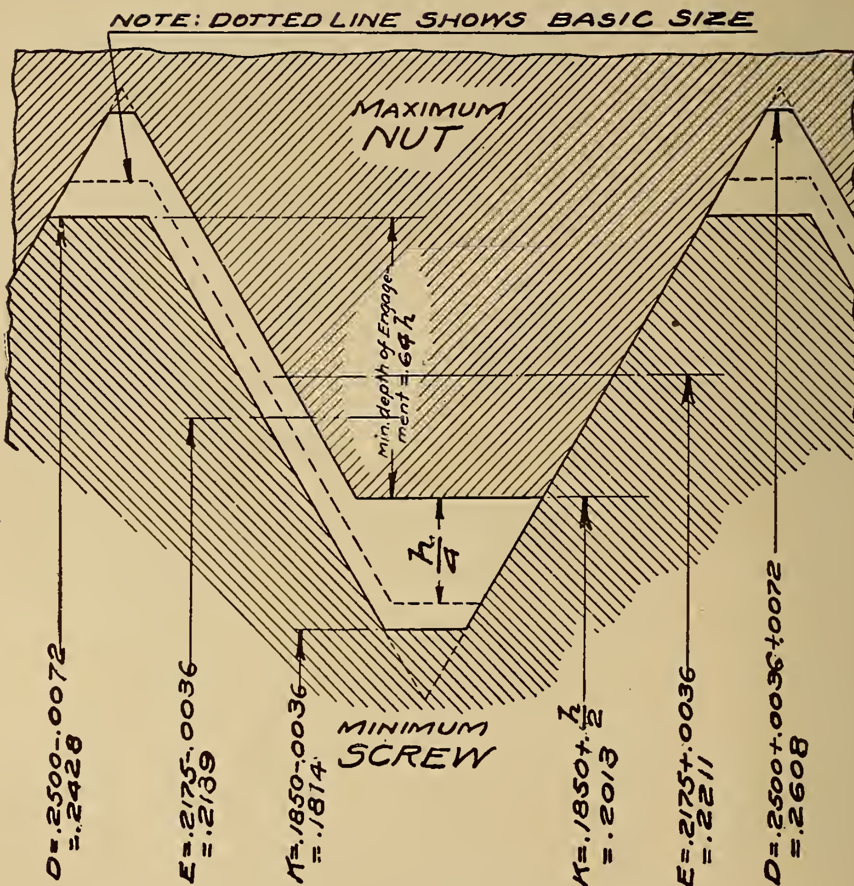


FIG. 12.—*Tolerance values for Class II–A, medium fit regular*

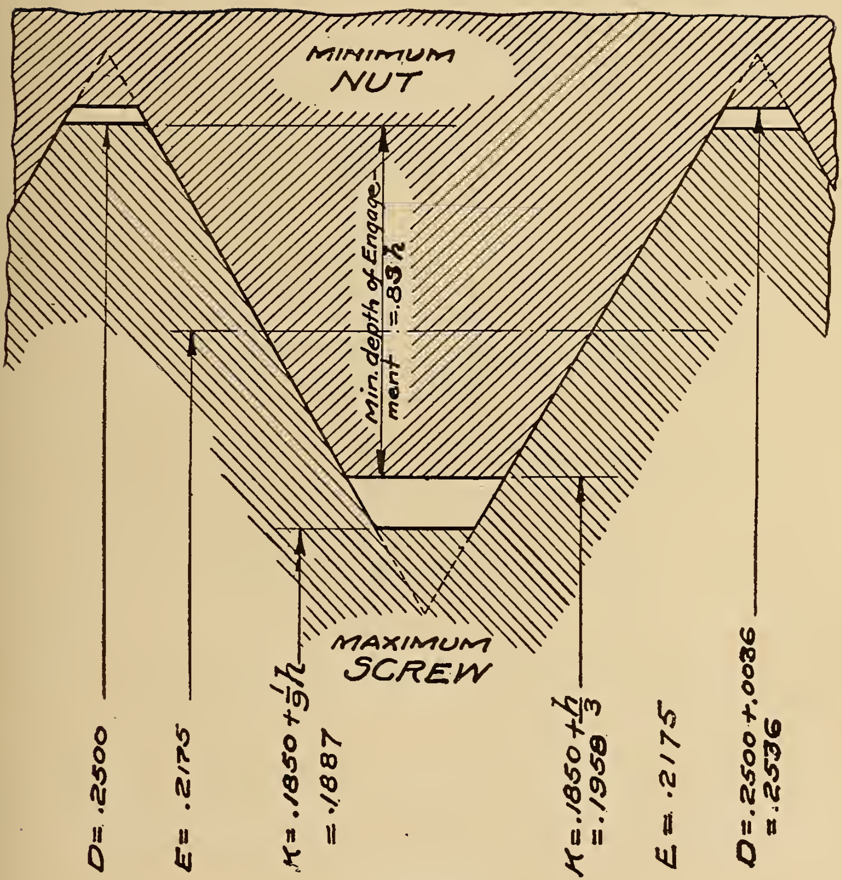


NOTATION

f=0.0054=Basic depth of truncation
h= .0325=Basic thread depth

D=Major diameter
E=Pitch diameter
K=Minor diameter

FIG. 13.—*Illustration of loosest condition for Class II–A, medium fit regular, ¼ inch, 20 threads*



NOTATION

f=0.0054=Basic depth of truncation

h= .0325=Basic thread depth

D=Major diameter

E=Pitch diameter

K=Minor diameter

FIG. 14.—*Illustration of tightest condition for Class II–A, medium fit regular and Class II–B, medium fit special, ¼ inch, 20 threads*

TABLE 10.—Class II-A, Medium Fit (Regular), Allowances and Tolerances for Screws, Nuts, and Gages

1	2	3	4	5	6		7
Threads per inch	Allowances	Extreme or drawing pitch diameter tolerances	Master-gage tolerances [a]				Net pitch diameter tolerances
			Diameter	Lead [b]	½ angle		
	Inch	Inch	Inch	Inch	Deg.	Min.	Inch
80	0.0000	0.0017	0.0002	±0.0002	±0	30	0.0013
72	.0000	.0018	.0002	± .0002	±0	30	.0014
64	.0000	.0019	.0002	± .0002	±0	30	.0015
56	.0000	.0020	.0002	± .0002	±0	30	.0016
48	.0000	.0022	.0002	± .0002	±	30	.0018
44	.0000	.0023	.0002	± .0002	±0	30	.0019
40	.0000	.0024	.0002	± .0002	±0	20	.0020
36	.0000	.0025	.0002	± .0002	±0	20	.0021
32	.0000	.0027	.0002	± .0002	±0	20	.0023
28	.0000	.0031	.0003	± .0002	±0	15	.0025
24	.0000	.0033	.0003	± .0002	±0	15	.0027
20	.0000	.0036	.0003	± .0002	±0	15	.0030
18	.0000	.0041	.0004	± .0003	±0	10	.0033
16	.0000	.0045	.0004	± .0003	±0	10	.0037
14	.0000	.0049	.0004	± .0003	±0	10	.0041
13	.0000	.0052	.0004	± .0003	±0	10	.0044
12	.0000	.0056	.0004	± .0003	±0	10	.0048
11	.0000	.0059	.0004	± .0003	±0	10	.0051
10	.0000	.0064	.0004	± .0004	±0	5	.0056
9	.0000	.0070	.0004	± .0004	±0	5	.0062
8	.0000	.0076	.0004	± .0004	±0	5	.0068
7	.0000	.0085	.0004	± .0004	±0	5	.0077
6	.0000	.0101	.0006	± .0005	±0	5	.0089
5	.0000	.0116	.0006	± .0005	±0	5	.0104
4½	.0000	.0127	.0006	± .0005	±0	5	.0115
4	.0000	.0140	.0006	± .0005	±0	5	.0128

[a] See "VI. Gages."
[b] Allowable variation in lead between any two threads not farther apart than the length of engagement.

TABLE 11.—Class II-A, Medium Fit (Regular), National Coarse-Thread Series

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Screw sizes						Nut sizes						
Sizes	Threads per inch	Major diameter		Pitch diameter		Minor diameter		Minor diameter		Pitch diameter		Major diameter		Basic major diameter
		Max.	Min.	Max.	Min.	Max.[a]	Min.	Min.	Max.	Min.	Max.	Min.[a]	Max.	
		Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1	64	0.073	0.0692	0.0629	0.0610	0.0538	0.0508	0.0561	0.0578	0.0629	0.0648	0.0741	0.0772	0.073
2	56	.086	.0820	.0744	.0724	.0641	.0608	.0667	.0686	.0744	.0764	.0873	.0906	.086
3	48	.099	.0946	.0855	.0833	.0734	.0697	.0764	.0787	.0855	.0877	.1005	.1042	.099
4	40	.112	.1072	.0958	.0934	.0813	.0771	.0849	.0876	.0958	.0982	.1138	.1180	.112
5	40	.125	.1202	.1088	.1064	.0943	.0901	.0979	.1006	.1088	.1112	.1268	.1310	.125
6	32	.138	.1326	.1177	.1150	.0997	.0947	.1042	.1076	.1177	.1204	.1403	.1452	.138
8	32	.164	.1586	.1437	.1410	.1257	.1207	.1302	.1336	.1437	.1464	.1663	.1712	.164
10	24	.190	.1834	.1629	.1596	.1389	.1326	.1449	.1494	.1629	.1662	.1930	.1993	.190
12	24	.216	.2094	.1889	.1856	.1649	.1586	.1709	.1754	.1889	.1922	.2190	.2253	.216
1/4	20	.2500	.2428	.2175	.2139	.1887	.1814	.1959	.2013	.2175	.2211	.2536	.2608	.2500
5/16	18	.3125	.3043	.2764	.2723	.2443	.2362	.2524	.2584	.2764	.2805	.3165	.3246	.3125
3/8	16	.3750	.3660	.3344	.3299	.2983	.2893	.3073	.3141	.3344	.3389	.3795	.3885	.3750
7/16	14	.4375	.4277	.3911	.3862	.3499	.3398	.3602	.3679	.3911	.3960	.4427	.4527	.4375
1/2	13	.5000	.4896	.4500	.4448	.4056	.3949	.4167	.4251	.4500	.4552	.5056	.5163	.5000
9/16	12	.5625	.5513	.5084	.5028	.4603	.4486	.4723	.4813	.5084	.5140	.5685	.5801	.5625
5/8	11	.6250	.6132	.5660	.5601	.5135	.5010	.5266	.5364	.5660	.5719	.6316	.6440	.6250
3/4	10	.7500	.7372	.6850	.6786	.6273	.6137	.6417	.6526	.6850	.6914	.7572	.7708	.7500
7/8	9	.8750	.8610	.8028	.7958	.7387	.7237	.7547	.7667	.8028	.8098	.8830	.8980	.8750
1	8	1.0000	.9848	.9188	.9112	.8466	.8300	.8647	.8782	.9188	.9264	1.0090	1.0256	1.0000
1 1/8	7	1.1250	1.1080	1.0322	1.0237	.9497	.9309	.9704	.9858	1.0322	1.0407	1.1353	1.1541	1.1250
1 1/4	7	1.2500	1.2330	1.1572	1.1487	1.0747	1.0559	1.0954	1.1108	1.1572	1.1657	1.2603	1.2791	1.2500
1 1/2	6	1.5000	1.4798	1.3917	1.3816	1.2955	1.2734	1.3196	1.3376	1.3917	1.4018	1.5120	1.5342	1.5000
1 3/4	5	1.7500	1.7268	1.6201	1.6085	1.5046	1.4786	1.5335	1.5551	1.6201	1.6317	1.7644	1.7905	1.7500
2	4 1/2	2.0000	1.9746	1.8557	1.8430	1.7274	1.6986	1.7594	1.7835	1.8557	1.8684	2.0160	2.0448	2.0000
2 1/4	4 1/2	2.2500	2.2246	2.1057	2.0930	1.9774	1.9486	2.0094	2.0335	2.1057	2.1184	2.2660	2.2948	2.2500
2 1/2	4	2.5000	2.4720	2.3376	2.3236	2.1933	2.1612	2.2294	2.2564	2.3376	2.3516	2.5180	2.5501	2.5000
2 3/4	4	2.7500	2.7220	2.5876	2.5736	2.4433	2.4112	2.4794	2.5064	2.5876	2.6016	2.7680	2.8001	2.7500
3	4	3.0000	2.9720	2.8376	2.8236	2.6933	2.6612	2.7294	2.7564	2.8376	2.8516	3.0180	3.0501	3.0000

[a] Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root. The dimensions given in the tables of screw and nut sizes are the limiting dimensions of the work and not of the gages.

TABLE 12.—Class II-A, Medium Fit (Regular), National Fine-Thread Series

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Screw sizes						Nut sizes						
Sizes	Threads per inch	Major diameter		Pitch diameter		Minor diameter		Minor diameter		Pitch diameter		Major diameter		Basic major diameter
		Max.	Min.	Max.	Min.	Max.[a]	Min.	Min.	Max.	Min.	Max.	Min.[a]	Max.	
		Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
0	80	0.060	0.0566	0.0519	0.0502	0.0447	0.0421	0.0465	0.0478	0.0519	0.0536	0.0609	0.0635	0.060
1	72	.073	.0694	.0640	.0622	.0560	.0532	.0580	.0595	.0640	.0658	.0740	.0768	.073
2	64	.086	.0822	.0759	.0740	.0668	.0638	.0691	.0708	.0759	.0778	.0871	.0902	.086
3	56	.099	.0950	.0874	.0854	.0771	.0738	.0797	.0816	.0874	.0894	.1003	.1036	.099
4	48	.112	.1076	.0985	.0963	.0864	.0827	.0894	.0917	.0985	.1007	.1135	.1172	.112
5	44	.125	.1204	.1102	.1079	.0971	.0932	.1004	.1029	.1102	.1125	.1266	.1306	.125
6	40	.138	.1332	.1218	.1194	.1073	.1031	.1109	.1136	.1218	.1242	.1398	.1440	.138
8	36	.164	.1590	.1460	.1435	.1299	.1254	.1339	.1369	.1460	.1485	.1660	.1705	.164
10	32	.190	.1846	.1697	.1670	.1517	.1467	.1562	.1596	.1697	.1724	.1923	.1972	.190
12	28	.216	.2098	.1928	.1897	.1722	.1665	.1773	.1812	.1928	.1959	.2186	.2243	.216
1/4	28	.2500	.2438	.2268	.2237	.2062	.2005	.2113	.2152	.2268	.2299	.2526	.2583	.2500
5/16	24	.3125	.3059	.2854	.2821	.2614	.2551	.2674	.2719	.2854	.2887	.3155	.3218	.3125
3/8	24	.3750	.3684	.3479	.3446	.3239	.3176	.3299	.3344	.3479	.3512	.3780	.3843	.3750
7/16	20	.4375	.4303	.4050	.4014	.3762	.3689	.3834	.3888	.4050	.4086	.4411	.4483	.4375
1/2	20	.5000	.4928	.4675	.4639	.4387	.4314	.4459	.4513	.4675	.4711	.5036	.5108	.5000
9/16	18	.5625	.5543	.5264	.5223	.4943	.4862	.5024	.5084	.5264	.5305	.5665	.5746	.5625
5/8	18	.6250	.6168	.5889	.5848	.5568	.5487	.5649	.5709	.5889	.5930	.6290	.6371	.6250
3/4	16	.7500	.7410	.7094	.7049	.6733	.6643	.6823	.6891	.7094	.7139	.7545	.7635	.7500
7/8	14	.8750	.8652	.8286	.8237	.7874	.7773	.7977	.8054	.8286	.8335	.8802	.8902	.8750
1	14	1.0000	.9902	.9536	.9487	.9124	.9023	.9227	.9304	.9536	.9585	1.0052	1.0152	1.0000
1 1/8	12	1.1250	1.1138	1.0709	1.0653	1.0228	1.0111	1.0348	1.0438	1.0709	1.0765	1.1310	1.1426	1.1250
1 1/4	12	1.2500	1.2388	1.1959	1.1903	1.1478	1.1361	1.1598	1.1688	1.1959	1.2015	1.2560	1.2676	1.2500
1 1/2	12	1.5000	1.4888	1.4459	1.4403	1.3978	1.3861	1.4098	1.4188	1.4459	1.4515	1.5060	1.5176	1.5000
1 3/4	12	1.7500	1.7388	1.6959	1.6903	1.6478	1.6361	1.6598	1.6688	1.6959	1.7015	1.7560	1.7676	1.7500
2	12	2.0000	1.9888	1.9459	1.9403	1.8978	1.8861	1.9098	1.9188	1.9459	1.9515	2.0060	2.0176	2.0000
2 1/4	12	2.2500	2.2388	2.1959	2.1903	2.1478	2.1361	2.1598	2.1688	2.1959	2.2015	2.2560	2.2676	2.2500
2 1/2	12	2.5000	2.4888	2.4459	2.4403	2.3978	2.3861	2.4098	2.4188	2.4459	2.4515	2.5060	2.5176	2.5000
2 3/4	12	2.7500	2.7388	2.6959	2.6903	2.6478	2.6361	2.6598	2.6688	2.6959	2.7015	2.7560	2.7676	2.7500
3	10	3.0000	2.9872	2.9350	2.9286	2.8773	2.8637	2.8917	2.9026	2.9350	2.9414	3.0072	3.0208	3.0000

[a] Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root. The dimensions given in the tables of screw and nut sizes are the limiting dimensions of the work and not of the gages.

(*d*) Class II–B, Medium Fit (Special).—This class of screw threads will be defined and specified as follows:

1. *Definition.*—The medium-fit class, Subdivision B, Special, is intended to apply especially to the higher grade of automobile screw-thread work. It is the same in every particular as Class II–A, Medium Fit (Regular), except that the tolerances are smaller.

2. *Minimum Nut Basic.*—The pitch diameter of the minimum nut of a given diameter and pitch will correspond to the basic pitch diameter as specified in tables of thread systems given herein which is computed from the basic major diameter of the thread to be manufactured.

3. *Maximum Screw Basic.*—The major diameter and pitch diameter of the maximum screw of a given pitch and diameter will correspond to the basic dimensions as specified in tables of thread systems given herein which are computed from the basic major diameter of the thread to be manufactured.

4. *Direction of Tolerance on Nut.*—The tolerance on the nut will be plus; to be applied from the basic size to above basic size.

5. *Direction of Tolerance on Screw.*[3]—The tolerance on the screw will be minus; to be applied from the maximum size to below maximum size.

6. *Zero Allowance.*—The allowance between the pitch diameter of the maximum screw and the minimum nut will be zero for all pitches and all diameters.

7. *Tolerance Values.*—The tolerance for a screw or nut of a given pitch will be as specified in Table 13.

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[3] The maximum minor diameter of the screw is above the basic minor diameter, as shown in Fig. 11.

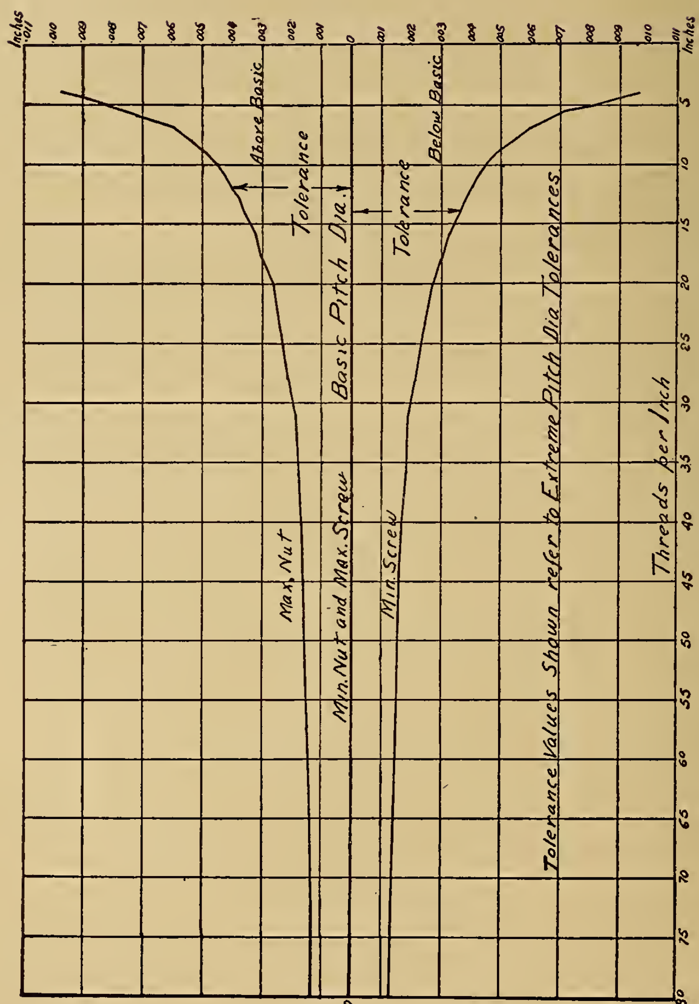
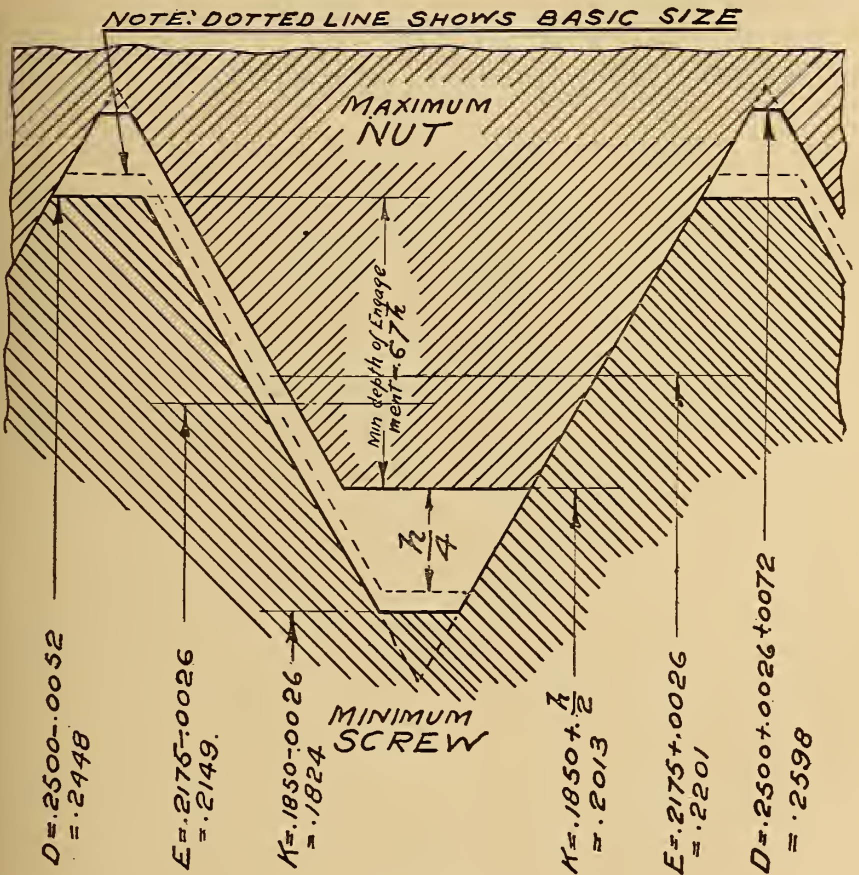


FIG. 15.—*Tolerance values for Class II–B, medium fit special*



NOTATION

f=0.0054=Basic depth of truncation
h= .0325=Basic thread depth
D=Major diameter
E=Pitch diameter
K=Minor diameter

FIG. 16.—*Illustration of loosest condition for Class II–B, medium fit special. For illustration of tightest condition for Class II–B, see Fig. 14, p. 37, ¼ inch, 20 threads*

TABLE 13.—Class II-B, Medium Fit (Special), Allowances and Tolerances for Screws, Nuts, and Gages

1	2	3	4	5	6	7
Threads per inch	Allowances	Extreme or drawing pitch diameter tolerances	Master-gage tolerances [a]			Net pitch diameter tolerances
			Diameter	Lead [b]	½ angle	
	Inch	Inch	Inch	Inch	Deg. Min.	Inch
80	0.0000	0.0013	0.0002	±0.0002	±0 30	0.0009
72	.0000	.0013	.0002	± .0002	±0 30	.0009
64	.0000	.0014	.0002	± .0002	±0 30	.0010
56	.0000	.0015	.0002	± .0002	±0 30	.0011
48	.0000	.0016	.0002	± .0002	±0 30	.0012
44	.0000	.0016	.0002	± .0002	±0 30	.0012
40	.0000	.0017	.0002	± .0002	±0 20	.0013
36	.0000	.0018	.0002	± .0002	±0 20	.0014
32	.0000	.0019	.0002	± .0002	±0 20	.0015
28	.0000	.0022	.0003	± .0002	±0 15	.0016
24	.0000	.0024	.0003	± .0002	±0 15	.0018
20	.0000	.0026	.0003	± .0002	±0 15	.0020
18	.0000	.0030	.0004	± .0003	±0 10	.0022
16	.0000	.0032	.0004	± .0003	±0 10	.0024
14	.0000	.0036	.0004	± .0003	±0 10	.0028
13	.0000	.0037	.0004	± .0003	±0 10	.0029
12	.0000	.0040	.0004	± .0003	±0 10	.0032
11	.0000	.0042	.0004	± .0003	±0 10	.0034
10	.0000	.0045	.0004	± .0004	±0 5	.0037
9	.0000	.0049	.0004	± .0004	±0 5	.0041
8	.0000	.0054	.0004	± .0004	±0 5	.0046
7	.0000	.0059	.0004	± .0004	±0 5	.0051
6	.0000	.0071	.0006	± .0005	±0 5	.0059
5	.0000	.0082	.0006	± .0005	±0 5	.0070
4½	.0000	.0089	.0006	± .0005	±0 5	.0077
4	.0000	.0097	.0006	± .0005	±0 5	.0085

[a] See "VI. Gages."
[b] Allowable variation in lead between any two threads not farther apart than the length of engagement.

TABLE 14.—Class II-B, Medium Fit (Special), National Coarse-Thread Series

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sizes	Threads per inch	Screw sizes						Nut sizes						Basic major diameter
		Major diameter		Pitch diameter		Minor diameter		Minor diameter		Pitch diameter		Major diameter		
		Max.	Min.	Max.	Min.	Max.[a]	Min.	Min.	Max.	Min.	Max.	Min.[a]	Max.	
		Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1..........	64	0.073	0.0702	0.0629	0.0615	0.0538	0.0513	0.0561	0.0578	0.0629	0.0643	0.0741	0.0767	0.073
2..........	56	.086	.0830	.0744	.0729	.0641	.0613	.0667	.0686	.0744	.0759	.0873	.0901	.086
3..........	48	.099	.0958	.0855	.0839	.0734	.0703	.0764	.0787	.0855	.0871	.1005	.1036	.099
4..........	40	.112	.1086	.0958	.0941	.0813	.0778	.0849	.0876	.0958	.0975	.1138	.1173	.112
5..........	40	.125	.1216	.1088	.1071	.0943	.0908	.0979	.1006	.1088	.1105	.1268	.1303	.125
6..........	32	.138	.1342	.1177	.1158	.0997	.0955	.1042	.1076	.1177	.1196	.1403	.1444	.138
8..........	32	.164	.1602	.1437	.1418	.1257	.1215	.1302	.1336	.1437	.1456	.1663	.1704	.164
10..........	24	.190	.1852	.1629	.1605	.1389	.1335	.1449	.1494	.1629	.1653	.1930	.1984	.190
12..........	24	.216	.2112	.1889	.1865	.1649	.1595	.1709	.1754	.1889	.1913	.2190	.2244	.216
¼..........	20	.2500	.2448	.2175	.2149	.1887	.1824	.1959	.2013	.2175	.2201	.2536	.2598	.2500
5/16..........	18	.3125	.3065	.2764	.2734	.2443	.2373	.2524	.2584	.2764	.2794	.3165	.3235	.3125
⅜..........	16	.3750	.3686	.3344	.3312	.2983	.2906	.3073	.3141	.3344	.3376	.3795	.3872	.3750
7/16..........	14	.4375	.4303	.3911	.3875	.3499	.3411	.3602	.3679	.3911	.3947	.4427	.4514	.4375
½..........	13	.5000	.4926	.4500	.4463	.4056	.3964	.4167	.4251	.4500	.4537	.5056	.5148	.5000
9/16..........	12	.5625	.5545	.5084	.5044	.4603	.4502	.4723	.4813	.5084	.5124	.5685	.5785	.5625
⅝..........	11	.6250	.6166	.5660	.5618	.5135	.5027	.5266	.5364	.5660	.5702	.6316	.6423	.6250
¾..........	10	.7500	.7410	.6850	.6805	.6273	.6156	.6417	.6526	.6850	.6895	.7572	.7689	.7500
⅞..........	9	.8750	.8652	.8028	.7979	.7387	.7258	.7547	.7667	.8028	.8077	.8830	.8959	.8750
1..........	8	1.0000	.9892	.9188	.9134	.8466	.8322	.8647	.8782	.9188	.9242	1.0090	1.0234	1.0000
1⅛..........	7	1.1250	1.1132	1.0322	1.0263	.9497	.9335	.9704	.9858	1.0322	1.0381	1.1353	1.1515	1.1250
1¼..........	7	1.2500	1.2382	1.1572	1.1513	1.0747	1.0585	1.0954	1.1108	1.1572	1.1631	1.2603	1.2765	1.2500
1½..........	6	1.5000	1.4858	1.3917	1.3846	1.2955	1.2764	1.3196	1.3376	1.3917	1.3988	1.5120	1.5312	1.5000
1¾..........	5	1.7500	1.7336	1.6201	1.6119	1.5046	1.4820	1.5335	1.5551	1.6201	1.6283	1.7644	1.7871	1.7500
2..........	4½	2.0000	1.9822	1.8557	1.8468	1.7274	1.7024	1.7594	1.7835	1.8557	1.8646	2.0160	2.0410	2.0000
2¼..........	4½	2.2500	2.2322	2.1057	2.0968	1.9774	1.9524	2.0094	2.0335	2.1057	2.1146	2.2660	2.2910	2.2500
2½..........	4	2.5000	2.4806	2.3376	2.3279	2.1933	2.1655	2.2294	2.2564	2.3376	2.3473	2.5180	2.5458	2.5000
2¾..........	4	2.7500	2.7306	2.5876	2.5779	2.4433	2.4155	2.4794	2.5064	2.5876	2.5973	2.7680	2.7958	2.7500
3..........	4	3.0000	2.9806	2.8376	2.8279	2.6933	2.6655	2.7294	2.7564	2.8376	2.8473	3.0180	3.0458	3.0000

[a] Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root. The dimensions given in the tables of screw and nut sizes are the limiting dimensions of the work and not of the gages.

TABLE 15.—CLASS II-B, Medium Fit (Special), National Fine-Thread Series

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Screw sizes						Nut sizes						
Sizes	Threads per inch	Major diameter		Pitch diameter		Minor diameter		Minor diameter		Pitch diameter		Major diameter		Basic major diameter
		Max.	Min.	Max.	Min.	Max.[a]	Min.	Min.	Max.	Min.	Max.	Min.[a]	Max.	
		Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
0	80	0.060	0.0574	0.0519	0.0506	0.0447	0.0425	0.0465	0.0478	0.0519	0.0532	0.0609	0.0631	0.060
1	72	.073	.0704	.0640	.0627	.0560	.0537	.0580	.0595	.0640	.0653	.0740	.0763	.073
2	64	.086	.0832	.0759	.0745	.0668	.0643	.0691	.0708	.0759	.0773	.0871	.0897	.086
3	56	.099	.0960	.0874	.0859	.0771	.0743	.0797	.0816	.0874	.0889	.1003	.1031	.099
4	48	.112	.1088	.0985	.0969	.0864	.0833	.0894	.0917	.0985	.1001	.1135	.1166	.112
5	44	.125	.1218	.1102	.1086	.0971	.0939	.1004	.1029	.1102	.1118	.1266	.1299	.125
6	40	.138	.1346	.1218	.1201	.1073	.1038	.1109	.1136	.1218	.1235	.1398	.1433	.138
8	36	.164	.1604	.1460	.1442	.1299	.1261	.1339	.1369	.1460	.1478	.1660	.1698	.164
10	32	.190	.1862	.1697	.1678	.1517	.1475	.1562	.1596	.1697	.1716	.1923	.1964	.190
12	28	.216	.2116	.1928	.1906	.1722	.1674	.1773	.1812	.1928	.1950	.2186	.2234	.216
1/4	28	.2500	.2456	.2268	.2246	.2062	.2014	.2113	.2152	.2268	.2290	.2526	.2574	.2500
5/16	24	.3125	.3077	.2854	.2830	.2614	.2560	.2674	.2719	.2854	.2878	.3155	.3209	.3125
3/8	24	.3750	.3702	.3479	.3455	.3239	.3185	.3299	.3344	.3479	.3503	.3780	.3834	.3750
7/16	20	.4375	.4323	.4050	.4024	.3762	.3699	.3834	.3888	.4050	.4076	.4411	.4473	.4375
1/2	20	.5000	.4948	.4675	.4649	.4387	.4324	.4459	.4513	.4675	.4701	.5036	.5098	.5000
9/16	18	.5625	.5565	.5264	.5234	.4943	.4873	.5024	.5084	.5264	.5294	.5665	.5735	.5625
5/8	18	.6250	.6190	.5889	.5859	.5568	.5498	.5649	.5709	.5889	.5919	.6290	.6360	.6250
3/4	16	.7500	.7436	.7094	.7062	.6733	.6656	.6823	.6891	.7094	.7126	.7545	.7622	.7500
7/8	14	.8750	.8678	.8286	.8250	.7874	.7786	.7977	.8054	.8286	.8322	.8802	.8889	.8750
1	14	1.0000	.9928	.9536	.9500	.9124	.9036	.9227	.9304	.9536	.9572	1.0052	1.0139	1.0000
1 1/8	12	1.1250	1.1170	1.0709	1.0669	1.0228	1.0127	1.0348	1.0438	1.0709	1.0749	1.1310	1.1410	1.1250
1 1/4	12	1.2500	1.2420	1.1959	1.1919	1.1478	1.1377	1.1598	1.1688	1.1959	1.1999	1.2560	1.2660	1.2500
1 1/2	12	1.5000	1.4920	1.4459	1.4419	1.3978	1.3877	1.4098	1.4188	1.4459	1.4499	1.5060	1.5160	1.5000
1 3/4	12	1.7500	1.7420	1.6959	1.6919	1.6478	1.6377	1.6598	1.6688	1.6959	1.6999	1.7560	1.7660	1.7500
2	12	2.0000	1.9920	1.9459	1.9419	1.8978	1.8877	1.9098	1.9188	1.9459	1.9499	2.0060	2.0160	2.0000
2 1/4	12	2.2500	2.2420	2.1959	2.1919	2.1478	2.1377	2.1598	2.1688	2.1959	2.1999	2.2560	2.2660	2.2500
2 1/2	12	2.5000	2.4920	2.4459	2.4419	2.3978	2.3877	2.4098	2.4188	2.4459	2.4499	2.5060	2.5160	2.5000
2 3/4	12	2.7500	2.7420	2.6959	2.6919	2.6478	2.6377	2.6598	2.6688	2.6959	2.6999	2.7560	2.7660	2.7500
3	10	3.0000	2.9910	2.9350	2.9305	2.8773	2.8656	2.8917	2.9026	2.9350	2.9395	3.0072	3.0189	3.0000

[a] Dimensions given are figured to the intersection of the worn tool arc with a centerline through crest and root. The dimensions given in the tables of screw and nut sizes are the limiting dimensions of the work and not of the gages.

(*e*) CLASS III, CLOSE FIT.—The close-fit class of screw threads will be defined and specified as follows:

1. Definition.—This class is intended for threaded work of the finest commercial quality, where the thread has practically no back lash, and for light screwdriver fits. In the manufacture of screw-thread products belonging in this class it will be necessary to use precision tools, selected master gages, and many other refinements. This quality of work should, therefore, be used only in cases where requirements of the mechanism being produced are exacting, or where special conditions require screws having a precision fit. In order to secure the fit desired it may be necessary in some cases to select the parts when the product is being assembled.

2. Minimum Nut Basic.—The pitch diameter of the minimum nut of a given diameter and pitch will correspond to the basic pitch diameter as specified in tables of thread systems given herein which is computed from the basic major diameter of the thread to be manufactured.

3. Maximum Screw Above Basic.—The major diameter and pitch diameter of the maximum screw of a given diameter and pitch will be above the basic dimensions as specified in tables of thread systems given herein which are computed from the basic major diameter of the thread to be manufactured by the amount of the allowance (interference) specified in Table 16.

4. Direction of Tolerance on Nut.—The tolerance on the nut will be plus; to be applied from the basic size to above basic size.

5. Direction of Tolerance on Screw.—The tolerance on the screw will be minus; to be applied from the maximum screw dimensions to below the maximum screw dimensions.

6. Allowance Values.—The allowance (interference) provided between the pitch diameter of the minimum nut, which is basic, and that of the maximum screw, which is above basic, will be as specified in Table 16.

7. Tolerance Values.—The tolerance for a screw or nut of a given pitch will be as specified in Table 16.

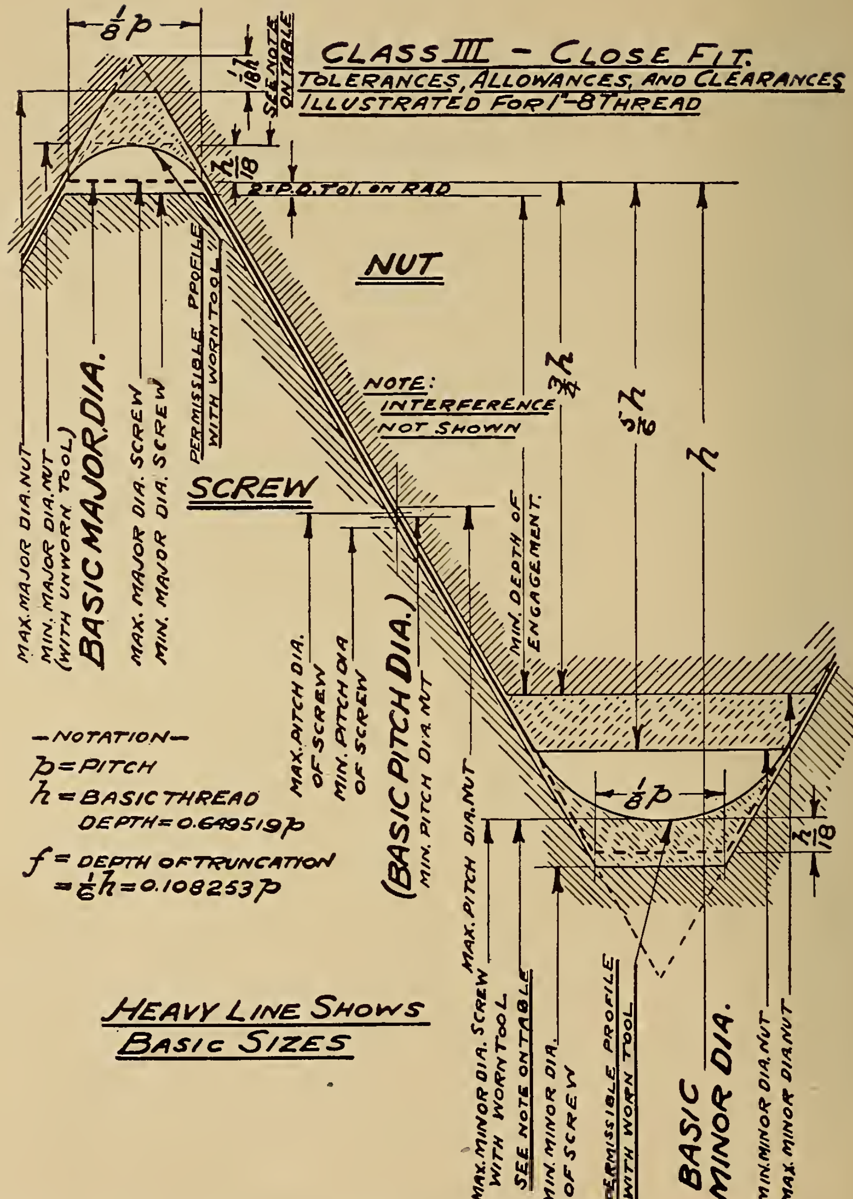


Fig. 17.—*Illustration of tolerance and allowance (interference) for Class III, close fit*

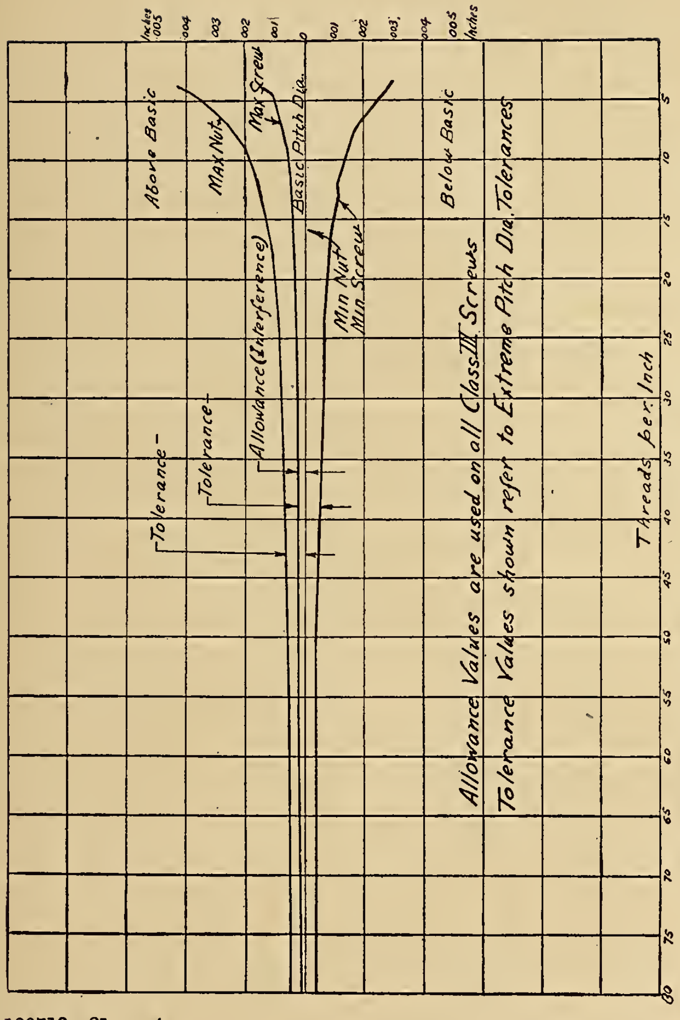
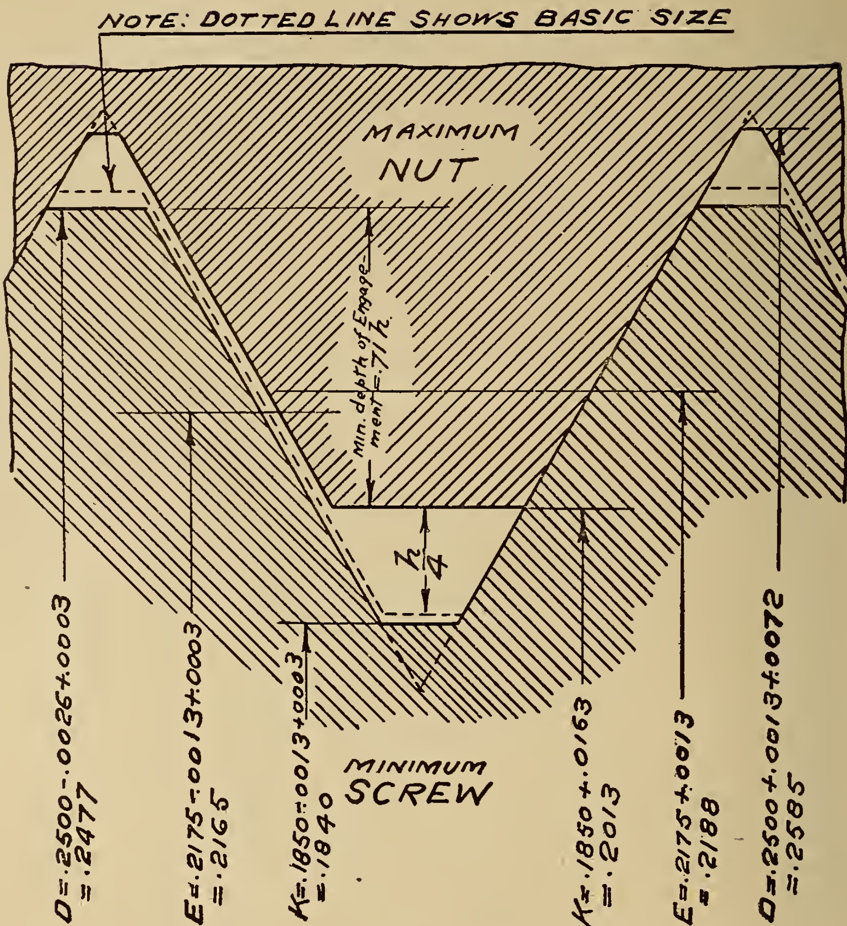


Fig. 18.—*Tolerance and allowance (interference) values for Class III, close fit*

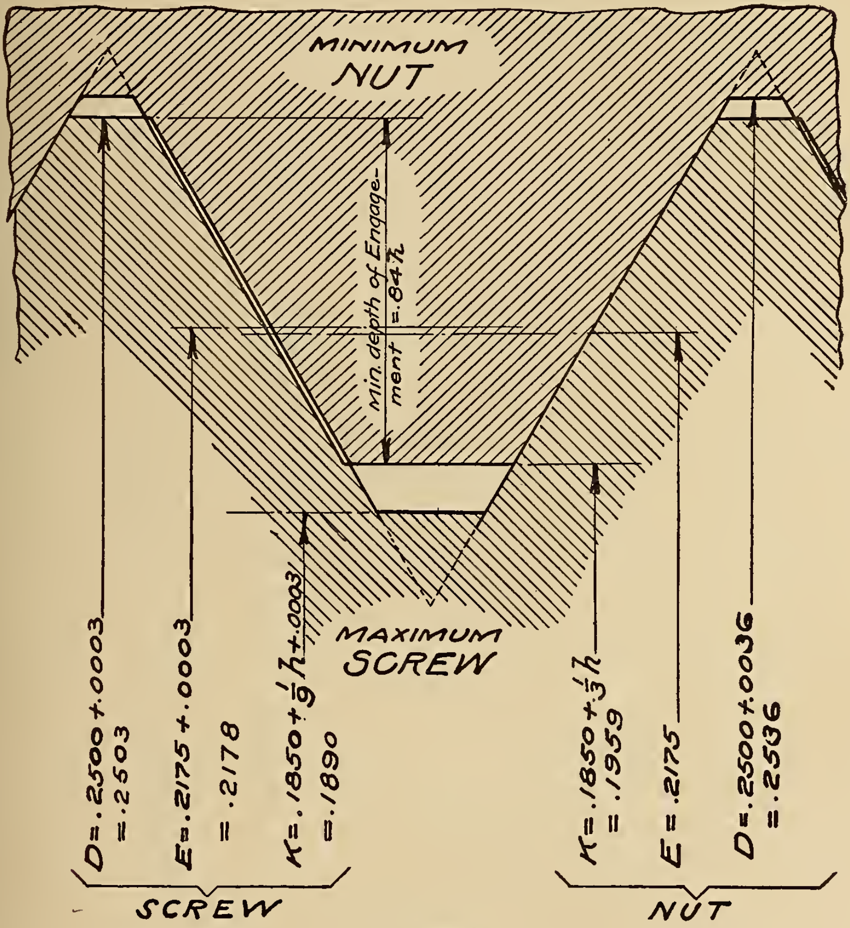


NOTATION

f=0.0054=Basic depth of truncation
h= .0325=Basic thread depth

D=Major diameter
E=Pitch diameter
K=Minor diameter

FIG. 19.—*Illustration of loosest condition for Class III, close fit, ¼ inch, 20 threads*



NOTATION

f=0.0054=Basic depth of truncation	D=Major diameter
h= .0325=Basic thread depth	E=Pitch diameter
	K=Minor diameter

FIG. 20.—*Illustration of tightest condition for Class III, close fit, 1/4 inch, 20 threads*

TABLE 16.—Class III, Close Fit, Allowances and Tolerances for Screws, Nuts, and Gages

1	2	3	4	5	6		7
Threads per inch	Interference or negative allowances	Extreme or drawing pitch diameter tolerances	Master-gage tolerances [a]				Net pitch diameter tolerances
			Diameter	Lead [b]	½ angle		
	Inch	Inch	Inch	Inch	Min.	Sec.	Inch
80	0.0001	0.0006	0.0001	±0.0001	±15	00	0.0004
72	.0001	.0007	.0001	± .0001	±15	00	.0005
64	.0001	.0007	.0001	± .0001	±15	00	.0005
56	.0002	.0007	.0001	± .0001	±15	00	.0005
48	.0002	.0008	.0001	± .0001	±15	00	.0006
44	.0002	.0008	.0001	± .0001	±15	00	.0006
40	.0002	.0009	.0001	± .0001	±10	00	.0007
36	.0002	.0009	.0001	± .0001	±10	00	.0007
32	.0002	.0010	.0001	± .0001	±10	00	.0008
28	.0002	.0011	.00015	± .0001	± 7	30	.0008
24	.0003	.0012	.00015	± .0001	± 7	30	.0009
20	.0003	.0013	.00015	± .0001	± 7	30	.0010
18	.0003	.0015	.0002	± .00015	± 5	00	.0011
16	.0004	.0016	.0002	± .00015	± 5	00	.0012
14	.0004	.0018	.0002	± .00015	± 5	00	.0014
13	.0004	.0019	.0002	± .00015	± 5	00	.0015
12	.0005	.0020	.0002	± .00015	± 5	00	.0016
11	.0005	.0021	.0002	± .00015	± 5	00	.0017
10	.0006	.0023	.0002	± .0002	± 2	30	.0019
9	.0006	.0024	.0002	± .0002	± 2	30	.0020
8	.0007	.0027	.0002	± .0002	± 2	30	.0023
7	.0008	.0030	.0002	± .0002	± 2	30	.0026
6	.0009	.0036	.0003	± .00025	± 2	30	.0030
5	.0010	.0041	.0003	± .00025	± 2	30	.0035
4½	.0011	.0044	.0003	± .00025	± 2	30	.0038
4	.0013	.0048	.0003	± .00025	± 2	30	.0042

[a] See "VI. Gages."
[b] Allowable variation in lead between any two threads not farther apart than the length of engagement

TABLE 17.—Class III, Close Fit, National Coarse-Thread Series

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sizes	Threads per inch	Screw sizes						Nut sizes						Basic major diameter
		Major diameter		Pitch diameter		Minor diameter		Minor diameter		Pitch diameter		Major diameter		
		Max.	Min.	Max.	Min.	Max.[a]	Min.	Min.	Max.	Min.	Max.	Min.[a]	Max.	
		Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1	64	0.0731	0.0717	0.0630	0.0623	0.0539	0.0521	0.0561	0.0578	0.0629	0.0636	0.0741	0.0760	0.073
2	56	.0862	.0848	.0746	.0739	.0643	.0623	.0667	.0686	.0744	.0751	.0873	.0893	.086
3	48	.0992	.0976	.0857	.0849	.0736	.0713	.0764	.0787	.0855	.0863	.1005	.1028	.099
4	40	.1122	.1104	.0960	.0951	.0815	.0788	.0849	.0876	.0958	.0967	.1138	.1165	.112
5	40	.1252	.1234	.1090	.1081	.0945	.0918	.0979	.1006	.1088	.1097	.1268	.1295	.125
6	32	.1382	.1362	.1179	.1169	.0999	.0966	.1042	.1076	.1177	.1187	.1403	.1435	.138
8	32	.1642	.1622	.1439	.1429	.1259	.1226	.1302	.1336	.1437	.1447	.1663	.1695	.164
10	24	.1903	.1879	.1632	.1620	.1392	.1350	.1449	.1494	.1629	.1641	.1930	.1972	.190
12	24	.2163	.2139	.1892	.1880	.1652	.1610	.1709	.1754	.1889	.1901	.2190	.2232	.216
1/4	20	.2503	.2477	.2178	.2165	.1890	.1840	.1959	.2013	.2175	.2188	.2536	.2585	.2500
5/16	18	.3128	.3098	.2767	.2752	.2446	.2391	.2524	.2584	.2764	.2779	.3165	.3220	.3125
3/8	16	.3754	.3722	.3348	.3332	.2987	.2926	.3073	.3141	.3344	.3360	.3795	.3856	.3750
7/16	14	.4379	.4343	.3915	.3897	.3503	.3433	.3602	.3679	.3911	.3929	.4427	.4496	.4375
1/2	13	.5004	.4966	.4504	.4485	.4060	.3986	.4167	.4251	.4500	.4519	.5056	.5130	.5000
9/16	12	.5630	.5590	.5089	.5069	.4608	.4527	.4723	.4813	.5084	.5104	.5685	.5765	.5625
5/8	11	.6255	.6213	.5665	.5644	.5140	.5053	.5266	.5364	.5660	.5681	.6316	.6402	.6250
3/4	10	.7506	.7460	.6856	.6833	.6279	.6184	.6417	.6526	.6850	.6873	.7572	.7667	.7500
7/8	9	.8756	.8708	.8034	.8010	.7393	.7289	.7547	.7667	.8028	.8052	.8830	.8934	.8750
1	8	1.0007	.9953	.9195	.9168	.8473	.8356	.8647	.8782	.9188	.9215	1.0090	1.0207	1.0000
1 1/8	7	1.1258	1.1198	1.0330	1.0300	.9505	.9372	.9704	.9858	1.0322	1.0352	1.1353	1.1486	1.1250
1 1/4	7	1.2508	1.2448	1.1580	1.1550	1.0755	1.0622	1.0954	1.1108	1.1572	1.1602	1.2603	1.2736	1.2500
1 1/2	6	1.5009	1.4937	1.3926	1.3890	1.2964	1.2808	1.3196	1.3376	1.3917	1.3953	1.5120	1.5277	1.5000
1 3/4	5	1.7510	1.7428	1.6211	1.6170	1.5056	1.4871	1.5335	1.5551	1.6201	1.6242	1.7644	1.7830	1.7500
2	4 1/2	2.0011	1.9923	1.8568	1.8524	1.7285	1.7080	1.7594	1.7835	1.8557	1.8601	2.0160	2.0365	2.0000
2 1/4	4 1/2	2.2511	2.2423	2.1068	2.1024	1.9785	1.9580	2.0094	2.0335	2.1057	2.1101	2.2660	2.2865	2.2506
2 1/2	4	2.5013	2.4917	2.3389	2.3341	2.1946	2.1717	2.2294	2.2564	2.3376	2.3424	2.5180	2.5409	2.5000
2 3/4	4	2.7513	2.7417	2.5889	2.5841	2.4446	2.4217	2.4794	2.5064	2.5876	2.5924	2.7680	2.7909	2.7500
3	4	3.0013	2.9917	2.8389	2.8341	2.6946	2.6717	2.7294	2.7564	2.8376	2.8424	3.0180	3.0409	3.0000

[a] Dimensions given are figured to the intersection of the worn tool are with a center line through crest and root. The dimensions given in the tables of screw and nut sizes are the limiting dimensions of the work and not of the gages.

TABLE 18.—Class III, Close Fit, National Fine-Thread Series

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sizes	Threads per inch	Screw sizes						Nut sizes						Basic major diameter
		Major diameter		Pitch diameter		Minor diameter		Minor diameter		Pitch diameter		Major diameter		
		Max.	Min.	Max.	Min.	Max.[a]	Min.	Min.	Max.	Min.	Max.	Min.[a]	Max.	
		Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
0	80	0.0601	0.0589	0.0520	0.0514	0.0448	0.0433	0.0465	0.0478	0.0519	0.0525	0.0609	0.0624	0.060
1	72	.0731	.0717	.0641	.0634	.0561	.0544	.0580	.0595	.0640	.0647	.0740	.0757	.073
2	64	.0861	.0847	.0760	.0753	.0669	.0651	.0691	.0708	.0759	.0766	.0871	.0890	.086
3	56	.0992	.0978	.0876	.0869	.0773	.0753	.0797	.0816	.0874	.0881	.1003	.1023	.099
4	48	.1122	.1106	.0987	.0979	.0866	.0843	.0894	.0917	.0985	.0993	.1135	.1158	.112
5	44	.1252	.1236	.1104	.1096	.0973	.0949	.1004	.1029	.1102	.1110	.1266	.1291	.125
6	40	.1382	.1364	.1220	.1211	.1075	.1048	.1109	.1136	.1218	.1227	.1398	.1425	.138
8	36	.1642	.1624	.1462	.1453	.1301	.1272	.1339	.1369	.1460	.1469	.1660	.1689	.164
10	32	.1902	.1882	.1699	.1689	.1519	.1486	.1562	.1596	.1697	.1707	.1923	.1955	.190
12	28	.2162	.2140	.1930	.1919	.1724	.1687	.1773	.1812	.1928	.1939	.2186	.2223	.216
1/4	28	.2502	.2480	.2270	.2259	.2064	.2027	.2113	.2152	.2268	.2279	.2526	.2563	.2500
5/16	24	.3128	.3104	.2857	.2845	.2617	.2575	.2674	.2719	.2854	.2866	.3155	.3197	.3125
3/8	24	.3753	.3729	.3482	.3470	.3242	.3200	.3299	.3344	.3479	.3491	.3780	.3822	.3750
7/16	20	.4378	.4352	.4053	.4040	.3765	.3715	.3834	.3888	.4050	.4063	.4411	.4460	.4375
1/2	20	.5003	.4977	.4678	.4665	.4390	.4340	.4459	.4513	.4675	.4688	.5036	.5085	.5000
9/16	18	.5628	.5598	.5267	.5252	.4946	.4891	.5024	.5084	.5264	.5279	.5665	.5720	.5625
5/8	18	.6253	.6223	.5892	.5877	.5571	.5516	.5649	.5709	.5889	.5904	.6290	.6345	.6250
3/4	16	.7504	.7472	.7098	.7082	.6737	.6676	.6823	.6891	.7094	.7110	.7545	.7606	.7500
7/8	14	.8754	.8718	.8290	.8272	.7878	.7808	.7977	.8054	.8286	.8304	.8802	.8871	.8750
1	14	1.0004	.9968	.9540	.9522	.9128	.9058	.9227	.9304	.9536	.9554	1.0052	1.0121	1.0000
1 1/8	12	1.1255	1.1215	1.0714	1.0694	1.0233	1.0152	1.0348	1.0438	1.0709	1.0729	1.1310	1.1390	1.1250
1 1/4	12	1.2505	1.2465	1.1964	1.1944	1.1483	1.1402	1.1598	1.1688	1.1959	1.1979	1.2560	1.2640	1.2500
1 1/2	12	1.5005	1.4965	1.4464	1.4444	1.3983	1.3902	1.4098	1.4188	1.4459	1.4479	1.5060	1.5140	1.5000
1 3/4	12	1.7505	1.7465	1.6964	1.6944	1.6483	1.6402	1.6598	1.6688	1.6959	1.6979	1.7560	1.7640	1.7500
2	12	2.0005	1.9965	1.9464	1.9444	1.8983	1.8902	1.9098	1.9188	1.9459	1.9479	2.0060	2.0140	2.0000
2 1/4	12	2.2505	2.2465	2.1964	2.1944	2.1483	2.1402	2.1598	2.1688	2.1959	2.1979	2.2560	2.2640	2.2500
2 1/2	12	2.5005	2.4965	2.4464	2.4444	2.3983	2.3902	2.4098	2.4188	2.4459	2.4479	2.5060	2.5140	2.5000
2 3/4	12	2.7505	2.7465	2.6964	2.6944	2.6483	2.6402	2.6598	2.6688	2.6959	2.6979	2.7560	2.7640	2.7500
3	10	3.0006	2.9960	2.9356	2.9333	2.8779	2.8684	2.8917	2.9026	2.9350	2.9373	3.0072	3.0167	3.0000

[a] Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root. The dimensions given in the tables of screw and nut sizes are the limiting dimensions of the work and not of the gages.

(*f*) Class IV, Wrench Fit.—The wrench-fit class of screw threads will be defined and specified as follows:

1. Definition.—This class is intended to cover the manufacture of threaded parts one-fourth inch diameter or larger which are to be set or assembled permanently with a wrench. Inasmuch as for wrench fits, the material is an important factor in determining the fit between the threaded members, there are provided herein two subdivisions for this class of work, namely, Subdivision A and Subdivision B. These two subdivisions differ mainly in the amount of the allowance (interference) values provided for different pitches.

Subdivision A of Class IV, Wrench Fit, provides for the production of interchangeable wrench-fit screws or studs used in light sections with moderate stresses, such as for aircraft and automobile engine work.

Subdivision B of Class IV, Wrench Fit, provides for the production of interchangeable wrench-fit screws or studs used in heavy sections with heavy stresses, such as for steam-engine and heavy hydraulic work.

2. Minimum Nut Basic.—The pitch diameter of the minimum nut of a given diameter and pitch for threads belonging in either Subdivision A or Subdivision B will correspond to the basic pitch diameter as specified in tables of thread systems given herein, which is computed from the basic major diameter of the thread to be manufactured.

3. Maximum Screw above Basic.—The major diameter and pitch diameter of the maximum screw of a given diameter and pitch for threads belonging in either Subdivision A or Subdivision B will be above the basic dimensions as specified in tables of thread systems given herein, which are computed from the basic major diameter of the thread to be manufactured, by the amount of the allowance (interference) provided.

4. Direction of Tolerance on Nut.—The tolerance on the nut will be plus; to be applied from the basic size to above basic size.

5. Direction of Tolerance on Screw.—The tolerance on the screw will be minus; to be applied from the maximum screw dimensions to below maximum screw dimensions.

6. Allowance and Tolerance Values not Included.—At the present time the commission does not have sufficient information or data to include in its progress report values for tolerances and allow ances for wrench fits. It is hoped, however, that sufficient information resulting from investigation and research will enable the commission to decide, at an early date, the allowance and tolerance values for the two classes of wrench fits included herein, which will be applicable to the various materials and which will meet the requirements found in manufacture of machines or product requiring wrench fits.

3. TOLERANCES

There are specified herein for use in connection with the various fits established, three different sets of tolerances as given in Tables 5, 10, 13, and 16.

(*a*) Tolerances Represent Extreme Variations.—The tolerances as hereinafter specified represent the extreme variations allowed on the work.[4]

(*b*) Pitch Diameter Tolerances Include Lead and Angle Variations.—The tolerance limits established represent, in reality, the sizes of the "Go" and "Not Go" master gages. Errors in lead and angle which occur on the threaded work can be offset by a suitable alteration of the pitch diameter of the work. If the "Go" gage passes the threaded work interchangeability is secured and the thread profile may differ from that of the "Go" gage in either pitch diameter, lead, or angle. The "Not Go" gage checks pitch diameter only, and thus insures that the pitch diameter is such that the fit will not be too loose. (See Appendix 5 for further explanation.)

(*c*) Class I and Class II Tolerances Permit the Use of Commercial Taps.—The tolerances established for Class I, Loose Fit, and Class II, Medium Fit, permit the use of commercial taps now obtainable from various manufacturers. For Class III, Close Fit, in which it is desired to produce a hole close to the basic size, it is recommended that a selected tap be used.

(*d*) Pitch Diameter Tolerances on Screw Same as on Nut.—The pitch diameter tolerances provided for a screw of a given class of fit will be the same as the pitch diameter tolerances provided for a nut corresponding to the same class of fit.

(*e*) Tolerances on Major Diameter of Screw Twice the Pitch Diameter Tolerances.—The allowable tolerances on the major diameter of screws of a given classification will be twice the tolerance values allowed on the pitch diameters of screws of the same class.

(*f*) Tolerances on Minor Diameter of Screw.—The minimum minor diameter of a screw of a given pitch will be such as to

[4] Recommendations and explanations regarding the application of tolerances are given in Appendix 5.

result in a basic flat ($\frac{1}{8} \times p$) at the root when the pitch diameter of the screw is at its minimum value. (*Note.*—When the maximum screw is basic, the minimum minor diameter of the screw will be below the *basic* minor diameter by the amount of the specified pitch diameter tolerance.)

The maximum minor diameter may be such as results from the use of a worn or rounded threading tool, when the pitch diameter is at its maximum value. In no case, however, should the form of the screw, as results from tool wear, be such as to cause the screw to be rejected on the maximum minor diameter by a "Go" ring gage, the minor diameter of which is equal to the minimum minor diameter of the nut.

(*g*) TOLERANCES ON MAJOR DIAMETER OF NUT.—The maximum major diameter of the nut of a given pitch will be such as to result in a flat one-third of the basic flat ($\frac{1}{24} \times p$) when the pitch diameter of the nut is at its maximum value. (*Note.*—When the minimum nut is basic, the maximum major diameter will be above the *basic* major diameter by the amount of the specified pitch diameter tolerance plus two-ninths of the basic thread depth.)

The nominal minimum major diameter of a nut will be above the basic major diameter by an amount equal to one-ninth of the basic thread depth plus the neutral space. This results in a clearance which is provided to facilitate manufacture by permitting a slight rounding or wear at the crest of the tap. In no case, however, should the minimum major diameter of the nut, as results from a worn tap or cutting tool, be such as to cause the nut to be rejected on the minimum major diameter by a "Go" plug gage made to the standard form at the crest.

(*h*) TOLERANCES ON MINOR DIAMETER OF NUT.—The tolerances on minor diameter of a nut of a given pitch will be one-sixth of the basic thread depth regardless of the class of fit being produced.

(*i*) ILLUSTRATION.—In Fig. 21 there are shown the various relations previously specified for tolerances on both the screw and the nut.

(*j*) SCOPE OF TOLERANCE SPECIFICATIONS.—The specifications establishing the various sets of tolerances for the different classes of fit specified herein will apply to the manufacture of National Coarse Threads, National Fine Threads, National Hose-Coupling Threads, National Fire-Hose Coupling Threads, Straight Pipe Threads, and wherever applicable to the production of all special threads.

Where tolerances are desired for a special thread and the pitch is not listed in the tables given, the tolerance values should be chosen corresponding to the number of threads per inch nearest to that of the special thread being produced. Where the number of threads per inch is midway between two of the pitches listed, the tolerance corresponding to the coarser pitch should be used. For instance, the tolerance on a screw having 11½ threads per inch would correspond to the tolerances specified for a screw of 11 threads per inch.

VI. GAGES

1. INTRODUCTORY

For the production of interchangeable threaded parts in large quantities, as provided for by specifications given under the subject of "Classification and Tolerances," it will be necessary to employ an adequate system of measuring or gaging the parts produced.

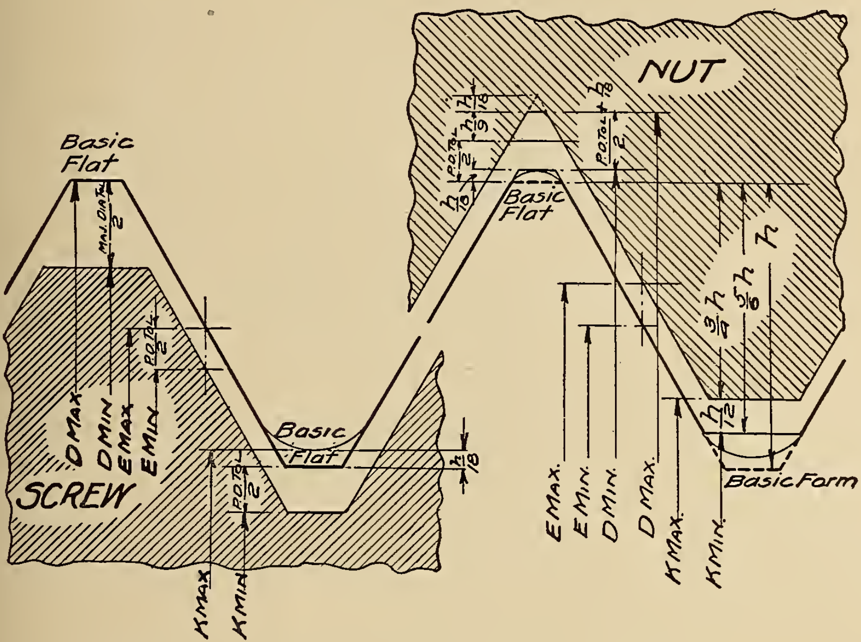
It is not the desire of the commission, nor is it wise at the present time, to lay down hard-and-fast specifications of a gaging system to meet the requirements of various manufacturers. To do this would not only cause hardship in certain lines of industry, but also would tend to limit progress in this important subject connected so closely with quantity production. It is felt, however, that inasmuch as at the present time the use of gages is the only known means of securing interchangeability, it is wise, especially in view of the experience and education gained during the recent World War, that certain fundamentals should be adopted which will serve as a unification of various gaging systems now in use by manufacturers in this country. A complete gaging system which has been found adequate in the production of war material is specified in detail in Appendix 6.

(*a*) Fundamentals.—(1) Standard Master Gage is the gage to which all other gages and all dimensions of the mating parts are ultimately checked or referred, either by direct check or by comparative measurements.

It clearly establishes the low limit of the threaded hole and the high limit of the screw at the point at which interference begins between mating parts.

(2) The tolerance limits of the component as physically represented by the Limit Master Gages must never be exceeded as a result either of errors or wear of the gages.

(Drawing shows one side of thread only and therefore spaces indicate half tolerances or tolerances on radii.)



Tol. major dia. screws = 2 × Tol. pitch dia.
Tol. minor dia. screws = Tol. pitch dia. + 2/3 f
= Tol. pitch dia. + 1/9 h
Tol. major dia. nuts = Tol. pitch dia. + 2/3 f
= Tol. pitch dia. + 1/9 h
Tol. minor dia. nuts = 1/6 h
D = Major diameter
E = Pitch diameter
K = Minor diameter
f = Depth of basic truncation
h = Depth of basic thread

FIG. 21.—*Relation between tolerance on pitch diameter, major diameter, and minor diameter*

(3) "Go" gages are absolutely essential to prevent interference of mating parts.

(4) "Not Go" gages are essential to prevent excess shake, play, or looseness of mating parts as determined by the extreme component limits.

(*b*) Gage Classification: *1. Standard Master Gage.*—The Standard Master Gage is a threaded plug representing as exactly as possible all physical dimensions of the nominal or basic size of the threaded component. In order that the Standard Master Gage be authentic, the deviations of this gage from the exact standard should be ascertained and certified by the National Bureau of Standards and, when used, its known errors should be taken into account.

2. Limit Master Gages.—The Limit Master Gages are threaded plugs representing as nearly as possible the exact limiting physical dimensions of the threaded mating parts as established by the specified tolerances. (For further information on limit gages see Appendix 6.)

A complete set of Limit Master Gages, in the form of threaded plugs, representing the maximum and minimum screw and nut dimensions for both the coarse and the fine series, and for all classes of fit, should be standardized by and kept at the National Bureau of Standards for use in settling any controversies that may arise with reference to the dimensions of other Limit Master Gages. The maximum ("Not Go") gages should be made to the maximum pitch diameter only. The major diameter and minor diameter should not be greater than the minimum specified for the minimum ("Go") gages. (See Appendix 6 (*c*) (5).)

3. Inspection Gages.—Inspection gages are for the use of the purchaser in accepting the product.

4. Working gages.—Working gages are those used by the manufacturer to check the parts produced as they are machined.

(*c*) Standard Temperature.—Gages and product should have their correct nominal dimensions at 68° F.

VII. NATIONAL PIPE THREADS

1. INTRODUCTORY

The material on the subject of pipe threads presented herewith was prepared by a special committee of the Committee of Manufacturers on Standardization of Fittings and Valves, acting in cooperation with pipe and gage manufacturers and the A. S.

M. E. committee on International Standards for Pipe Threads. It was published in October, 1919, under the title of "Manual on American Standard Pipe Threads." It has been indorsed by the American Society of Mechanical Engineers and the American Gas Association, and is adopted by the commission with only such changes as are necessary to bring it into conformity with the remainder of the report.

2. NATIONAL STANDARD PIPE THREADS

(Formerly known as American Standard Pipe Threads)

Indorsed by:

Committee of Manufacturers on Standardization of Fittings and Valves, 1927–1928 Whitehall Building, 17 Battery Place, New York, N. Y. Chairman; Howard Coonley, Walworth Manufacturing Co., Boston, Mass. Secretary: A. A. Ainsworth, 17 Battery Place, New York, N. Y.

Committee on Dimensions and Specifications: Chairman, A. M. Houser, Crane Co., Chicago, Ill.

Committee on Lists and Classifications: Chairman, J. S. Mattimore, The Kelly & Jones Co., New York, N. Y.

American Foundry & Construction Co., Pittsburgh, Pa.
American Valve Co., Coxsackie, N. Y.
Automatic Sprinkler Co. of America, 123 William Street, New York, City.
Crane Co., Chicago, Ill.
Darling Pump & Machinery Co. (Ltd.), Williamsport, Pa.
Detroit Brass Works, Detroit, Mich.
Detroit Lubricator Co., Detroit, Mich.
Thomas Devlin Manufacturing Co., Philadelphia, Pa.
Eddy Valve Co., Waterford, N. Y.
Essex Foundry, Newark, N. J.
The Fairbanks Co., New York, N. Y.
Stanley G. Flagg & Co., Philadelphia, Pa.
General Fire Extinguisher Co., Providence, R. I.
Illinois Malleable Iron Co., Chicago, Ill.
Jarecki Manufacturing Co., Erie, Pa.
H. J. Kattenthaler, Philadelphia, Pa.
The M. W. Kellog Co., New York, N. Y.
The Kelly & Jones Co., New York, N. Y.
The Kennedy Valve Manufacturing Co., Elmira, N. Y.
The Kerr Manufacturing Co., Walkerville, Ontario, Canada.
Kuhns Bros., Dayton, Ohio.
Ludlow Valve Manufacturing Co., Troy, N. Y.
The Lunkenheimer Co., Cincinnati, Ohio.
Malleable Iron Fittings Co., Branford, Conn.
T. McAvity & Sons (Ltd)., St. John, New Brunswick.
McNab & Harlin Manufacturing Co., New York, N. Y.
Nelson Valve Co., Philadelphia, Pa.
Ohio Brass Co., Mansfield, Ohio.
Pacific Foundry Co., San Francisco, Calif.
Pittsburgh Valve and Foundry Const. Co., Pittsburgh, Pa.
Pittsburgh Valve and Fittings Co., Barberton, Ohio.
The Wm. Powell Co., Cincinnati, Ohio.
The Pratt & Cady Co., (Inc)., Hartford, Conn.
The Stockham Pipe Fittings Co., Birmingham, Ala.
Walworth Manufacturing Co., Boston, Mass.
The D. T. Williams Co., Cincinnati, Ohio.
R. D. Wood & Co., Philadelphia, Pa.

Pipe Manufacturers:

National Tube Co., Pittsburgh, Pa.
Central Tube Co., Pittsburgh, Pa.
A. M. Byers Co., Pittsburgh, Pa.
Wheeling Steel & Iron Co., Wheeling, W. Va.
South Chester Tube Co., Chester, Pa.
Jones & Laughlin Steel Co., Pittsburgh, Pa.
Youngstown Sheet & Tube Co., Youngstown, Ohio.
Steel & Tube Co. of America, Chicago, Ill.
U. S. Steel Products Co., New York, N. Y.

Gage Manufacturers:

Pratt & Whitney Co., Hartford, Conn.
Greenfield Tap and Die Corporation, Greenfield, Mass.
Taft Peirce Manufacturing Co., Woonsocket, R. I.

History

The American Pipe-Thread Standard, also known as the American Briggs Standard, was formulated by Robert Briggs prior to 1882.

Mr. Briggs for several years was superintendent of the Pascal Iron Works of Morris, Tasker & Co., Philadelphia, and later was engineering editor of the Journal of the Franklin Institute. After his death, a paper by Mr. Briggs containing detailed information regarding American Pipe and Pipe-Thread practice was read before the Institution of Civil Engineers of Great Britain. This is recorded in the Excerpt minutes, Volume LXXI, Session 1882–1883, Part 1.

While, in a general way, American manufacturers were threading practically to the Briggs Standard, in 1886 the manufacturers and the American Society of Mechanical Engineers jointly adopted it in detail, and master gages were made. The standard has since been in general use in the United States and Canada.

At various conferences later, American manufacturers and the American Society of Mechanical Engineers established additional sizes, certain details of gaging, tolerances and special applications of the standard; also the formulas and dimensions were tabulated more completely than was originally done by Mr. Briggs.

Outline of Standard

The National (American) Pipe-Thread Standard establishes the following:

- Outside diameter of pipe,
- Diameter of external (male) thread,
- Diameter of internal (female) thread,
- Profile of thread,
- Pitch or lead of thread,
- Length of thread,
- Taper of thread,
- Engagement (by hand) of external and internal threads,
- Construction and use of gages,
- Tolerances,
- Use of taper threads,
- Use of straight threads.

Tables of Dimensions

The dimensions of National (American) Pipe Threads are expressed in inches to one one-hundred thousandth (0.00001) of an inch, and in millimeters to one one-thousandth (0.001) of a millimeter.

While this is a greater degree of accuracy than is ordinarily used, the dimensions are so expressed in order to eliminate errors which might result from less accurate dimensions.

The relation between the inch and the meter used in calculating the dimensions in these tables is that established by law in the United States and on record in the Bureau of Standards, Department of Commerce, Washington, D. C. This is

1 meter=39.37 inches exactly.

The metric equivalent of the inch resulting from this determination is

25.40005 millimeters=1 inch.

Outside Diameter of Pipe

The outside diameter of pipe is given in Column D of the table of dimensions. These diameters should be very closely adhered to by pipe manufacturers.

Diameter of Taper Thread

The pitch diameters of the taper thread are determined by formulas based on the outside diameter of pipe and the pitch of thread. These are as follows:

$$A=D-(0.05D+1.1)P.$$

$$B=A+0.0625L_1.$$

A=pitch diameter of thread at end of pipe.

B=pitch diameter of thread at gaging notch.

D=outside diameter of pipe.

L_1=normal engagement by hand between external and internal threads.

P=pitch of thread.

Note.—The above formulas are not expressed in the same terms as the formula originally established by Mr. Briggs, because they are used to determine pitch diameters, whereas the Briggs formula determined the major (outside) diameter of the thread. However, both forms give identical results.

Profile

The angle between the sides of the thread is 60° when measured in the axial plane, and the line bisecting this angle is perpendicular to the axis of the pipe, for taper or straight threads. (See Fig. 22.)

The crest and root are truncated an amount equal to $0.033P$. The depth of the thread, therefore, is $0.8P$. (See Fig. 22.)

Note.—While Mr. Briggs originally advocated a slightly rounded crest and root, the thread as applied in the manufacture of gages and thread tools has always been slightly flattened at the crest and root.

While the crests on commercially manufactured external and internal threads would appear slightly rounded when examined with a microscope, for all practical purposes they may be considered as sharp.

The roots of commercially manufactured threads are practically sharp when cut with new tools and slightly rounded when cut with worn tools.

Pitch

The pitch of a screw thread is the distance from a point on the thread to a corresponding point on the next thread, measured parallel to the axis.

Lead

The lead of a screw thread is the distance the screw will advance axially in one revolution. It is expressed in terms of the number of threads in 1 inch and the number of threads in 254 millimeters (254 mm equals 10 inches). On a single thread screw the lead and pitch are identical.

Length of Thread

The length of the taper external thread is determined by a formula based on the outside diameter of pipe and the pitch of the thread. This is as follows:

$$L_2=(0.8D+6.8)P.$$

L_2=length of effective thread.
D=outside diameter of pipe.
P=pitch of thread.

Note.—The above formula is not expressed in the same terms as the one originally established by Mr. Briggs, because it determines directly the length of effective thread which includes two threads slightly imperfect on the crest, whereas the Briggs formula determined the length of perfect thread, the two threads imperfect on the crest not being included in the formula. However, both forms give identical results.

Taper of Thread

The taper of the thread is 1 in 16 measured on the diameter.

Engagement Between Taper External (Male) and Internal (Female) Thread

The normal length of engagement between taper external and internal threads when screwed together by hand is shown in Column L_1 of Table 19.

This length is controlled by the construction and use of the gages.

Gages

Gages to properly maintain interchangeability of pipe threads should consist of Standard Master, Reference, Inspection, and Working Gages. The dimensions and functions of these gages are outlined below.

Standard Master Gage

The Standard Master Gage is a taper threaded plug gage. The roots of the threads are cut to a sharp V or may be undercut below the sharp V to facilitate the making of the thread. The crests are truncated an amount equal to $0.1P$. (See Fig. 25.) Otherwise the gage is made to the dimensions given in Table 19. This gage is provided with the gaging notch as illustrated in Fig. 23. The Standard Master Gage is the gage to which all other gages are ultimately referred either by transference of measurements or direct comparison by engagement. It is intended primarily for gage and thread tool manufacturers.

Reference Gages

The Reference Gages consist of a plug gage, similar in all respects to the Standard Master Gage, and two ring gages. One ring gage has a thickness equal to dimension L_1, is the same diameter at the small end as the small end of the plug gage, and is flush with the plug gage at the small end and at the gaging notch when screwed on tight by hand. (See Fig. 23.) The other ring gage has a thickness equal to dimension L_2, but is threaded for distance L_2–L_1. The distance equal to L_1 is counterbored and unthreaded. This gage is the same diameter at the large end as the large end of the plug gage. (See Fig. 24.) The Reference Plug Gage is used to inspect inspection and working taper threaded ring gages. The Reference Ring Gages are used to compare the reference plug with the standard master plug or the inspection and working plug gages with the reference plug gage.

Inspection Gages

Inspection Gages consist of one taper threaded plug gage and one taper threaded ring gage. The roots of the threads are cut to a sharp V or may be undercut to facilitate making the thread. The crests are truncated an amount equal to $0.1P$. (See Fig. 27.)[4] The ring gage has a thickness equal to dimension L_1, and the same diameter at the small end as the small end of the plug gage. (See Fig. 26.)

NOTE.—The object of truncating the crests on gages (truncation $0.1P$) is to insure that when gaging commercial threads cut with a slightly dull tool the gage bears on the sides of the thread instead of on the roots.

Inspection Gages are for the use of the purchaser of pipe thread products. When used, the extreme tolerance on the work should be applied. This tolerance is 1½ turns either way from the gaging notch in the case of internal threads inspected with the inspection plug gage, and when inspecting external threads the tolerance is 1½ turns either way from the small end of the inspection ring.

Working Gages

The Working Gages consist of one taper threaded plug gage and one taper threaded ring gage. These gages are similar in all respects to the inspection plug and ring gages. The Working Gages are used by the manufacturer to inspect his product. In using the Working Gages the tolerance to be applied is one turn either way from the gaging notch in case of internal threads inspected with the plug gage, and in the case of external threads the tolerance is one turn either way from the small end of the working ring gage.

Gaging Internal (Female) Threads

The Inspection and Working Plug Gages, Figs. 31 and 34, should screw tight by hand into the fitting or coupling until the notch is flush with the face. When the thread is chamfered, the notch should be flush with the bottom of the chamfer. The fitting or coupling is within the working or net tolerance if the working gage notch is within one turn of the coupling or fitting face when screwed in tight by hand. In the same way the coupling or fitting is within the inspection or extreme tolerance if the inspection gage notch is within 1½ turns of the coupling or fitting face when screwed on tight by hand.

This method of gaging is used either for taper internal threads or for straight internally threaded couplings which screw together with taper external threads. (See Figs. 31 and 34.)

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[4] Otherwise the gages are made to the dimensions given in Table 19.

Gaging Taper External (Male) Threads

The ring gage, Fig. 26, should screw tight by hand on the pipe or external thread until the small end of the gage is flush with the end of the thread. (See Fig. 28.) The pipe or external thread is within the working or net tolerance if the working gage ring screws on until on until the end of pipe or external thread is within one turn of the small end of the gage. The pipe or external thread is within the inspection or extreme tolerance if the inspection ring screws on until the end of pipe is within 1½ turns of the small end of the gage.

Gage Tolerances

Master Gages.—Master Gages should be made with the narrowest possible limits of error. In no case should the accumulative error exceed the total accumulative tolerance on diameter given in Table 26. Each Master Gage should be accompanied by a report showing the error on each of the elements of the thread and a statement of the accumulative error derived from the errors in the various elements.

Reference Gages.—Column 1 of Table 26 gives the maximum allowable cumulation of all errors in the thread surface of Reference Gages, expressed in terms of diameter, and is illustrated in Fig. 37. No point in the thread surface of the gage should be outside of the zone of tolerance indicated by the shaded portion of the illustration.

Note.—This column is used when checking gages by measurement. If the errors in the gage are reported in terms of pitch, angle of thread, and diameter, Tables 28 and 29 may be used to determine the cumulation of these errors for comparison with Column 1. In Table 28 the results of errors in angle are expressed in terms of diameter. In Table 29 the results of errors in pitch are expressed in terms of diameter. For example: A ¾″—14 plug pipe thread gage is reported as follows:

Pitch diameter, large end, 0.98881″.
Pitch diameter, small end, 0.96775″.
One-half included angle of thread, 29° 58′.
Maximum error in lead, 0.00007″.

The correct pitch diameter at large end is 0.98886″. (See Table 19.)
The error is 0.00005″.
The correct pitch diameter at small end is 0.96768″. (See Table 19.)
The error is 0.00007″.
2′ error in angle equals 0.00006″. (See Table 28.)
0.00007″ error in lead equals 0.00012″. (See Table 29.)
The cumulative error at large end in terms of diameter equals 0.00023″.
The cumulative error at small end equals 0.00025″.
The gage falls within the limits of the reference gage (0.00028″ as given in Table 26.)

Column 2 gives the equivalent of Column 1, expressed in terms of distance parallel to the axis, and represents the maximum distance which a reference ring gage of perfect thickness or a reference plug gage of perfect length from small end to gaging notch may vary from being flush at the gaging notch or at the small end, when referred to basic dimensions. It is equal to 16 times Column 1, owing to the basic taper of 1 in 16, measured on the diameter.

Note.—This column is used when checking reference gages by comparison with a master gage. The necessary allowance must be made for the error in the master.

Column 3 gives the equivalent of Column 2, expressed in terms of the decimal part of a turn from the basic dimensions.

Note.—This column is also used when checking reference gages by comparison with a master gage. The necessary allowance must be made for the error in the master.

A tolerance of plus or minus 0.0002 inch (0.005 millimeter) is allowed on the distance between the gaging notch and the small end of the reference plug gage, or on the thickness of the reference ring gage.

Note.—It is possible for reference plug and ring gages which come within all of the above tolerances to vary from being flush with each other at the small end, or at the gaging notch, when screwed together tight by hand. The maximum variation which might occur, expressed in terms of distance, is given in Column 4, and gages which come within these limits should be checked by measurement before being rejected.

Inspection Gages.—The tolerance on inspection gages will be the same as on reference gages. (See Table 26.)

New Working Gages.—Column 5 of Table 27 gives the maximum allowable cumulation of all errors in the thread surface of new working gages, expressed in terms of diameter, and is also illustrated in Fig. 37. No point in the thread surface of the gage should be outside of the zone of tolerance indicated by the shaded portion of the illustration.

NOTE.—This column is used when checking gages by measurement.

Column 6 gives the equivalent of Column 5, expressed in terms of distance parallel to the axis, and represents the maximum distance which a new working ring gage of perfect thickness or a new working plug gage of perfect length from small end to gaging notch may vary from being flush at the gaging notch, or at the small end, when referred to basic dimensions. It is equal to 16 times Column 5, owing to the basic taper of 1 in 16, measured on the diameter.

NOTE.—This column is used when checking working gages by comparison with a gage the error of which is known. The necessary allowance must be made for this error.

Column 7 gives the equivalent of Column 6, expressed in terms of the decimal part of a turn from basic dimensions.

NOTE.—This column is also used when checking working gages by comparison with a gage the error of which is known. The necessary allowance must be made for this error.

A tolerance of plus or minus 0.0005 inch (0.0127 mm) is allowed on the distance between the gaging notch and the small end of the working plug gage, or on the thickness of the working ring gage.

NOTE.—It is possible for working plug and ring gages which come within all of the above tolerances to vary from being flush with each other at the small end or at the gaging notch, when screwed together tight by hand. The maximum variation which might occur, expressed in terms of distance, is given in Column 8, and gages which come within these limits should be checked by comparison with reference gages before being rejected.

It is also possible for working plug and ring gages which come within all of the above tolerances to vary from being flush at the small end or at the gaging notch, when screwed tight by hand on a reference gage which comes within the tolerances specified for references gages. The maximum variation which might occur, expressed in terms of distance, is given in Column 9, and gages which come within these limits should be checked by measurement before being rejected.

Worn Working Gages.—The maximum wear on working gages must not be more than the equivalent of one-half turn from the basic dimensions.

In order that no work passed by the working gage shall be rejected by the inspection gage, it will be necessary to discontinue the use of the working gage when it has worn one-half turn. That is, the working gage should always be kept within the tolerance of one-half turn from the basic dimensions.

MANUFACTURING TOLERANCE

The maximum allowable variation in the commercial product is one turn plus or one turn minus from the gaging notch when using working gages. (See Figs. 29, 30, 32, and 33.) This is equivalent to a maximum allowable variation of one and one-half turns from the basic dimensions, owing to the allowance of one-half turn on working gages.

NATIONAL (AMERICAN) TAPER PIPE THREADS

Taper external and internal threads are recommended for threaded joints for any service.

National Straight Pipe Threads

Internal (*Female*).—Straight threaded internal wrought-iron or wrought-steel couplings of the weight known as "standard" may be used with taper threaded pipe for ordinary pressures, as they are sufficiently ductile to adjust themselves to the taper external thread when properly screwed together. For dimensions see Table 20.

For high pressures, only taper external and internal threads should be used.

External (*Male*).—Straight external threads are recognized only for special applications such as long screws, tank nipples.

Long Screws

Long screws are used to a limited extent. This joint is not considered satisfactory when subjected to temperature or pressure. In this application (see Fig. 35) the coupling has a straight thread and must make a joint with a National (American) Taper Pipe Thread.

In gaging, the National (American) Taper Working Plug Gage is used, allowing the same tolerance from the notch as for a taper thread. (See Fig. 34.) The straight thread on the pipe enters the coupling freely by hand, the joint being made by a packing material between the locknut and the coupling. (See Fig. 35.)

It is necessary that the coupling be screwed on the straight external thread for the full length of the coupling and then back until it engages the taper external thread.

Owing to the long engagement of thread, imperfections in pitch affect the fit when the coupling is screwed on the pipe its full length. Refinements of manufacture and gaging to insure a properly interchangeable product are more costly than the commercial use warrants; therefore, the use of this type of joint is not recommended.

Locknut Threads

Occasional requirements make it advisable to have a straight thread of the largest diameter it is possible to cut on a pipe. This has been standardized and is known as Maximum External and Minimum Internal Locknut Threads. For dimensions, see Table 21. The "tank nipple" shown in Fig. 36 is an example of this thread. In this application a National (American) Standard Taper Thread is cut on the end of the pipe after having first cut the External Locknut Thread.

Symbols

The list of symbols given in Section II–3, together with additional symbols given below, should be used in formulas for expressing relation of pipe threads and for use on drawings, etc.

A=pitch diameter of thread at end of pipe.

B=pitch diameter of thread at gaging notch.

C_1=maximum pitch diameter external locknut thread.

C_2=minimum pitch diameter internal locknut thread.

L_1=distance from gaging notch to end of pipe=normal engagement by hand.

L_2=length of effective thread.

D=nominal outside diameter of pipe=major diameter of pipe thread at L_2 from end of pipe.

d=internal diameter of pipe.

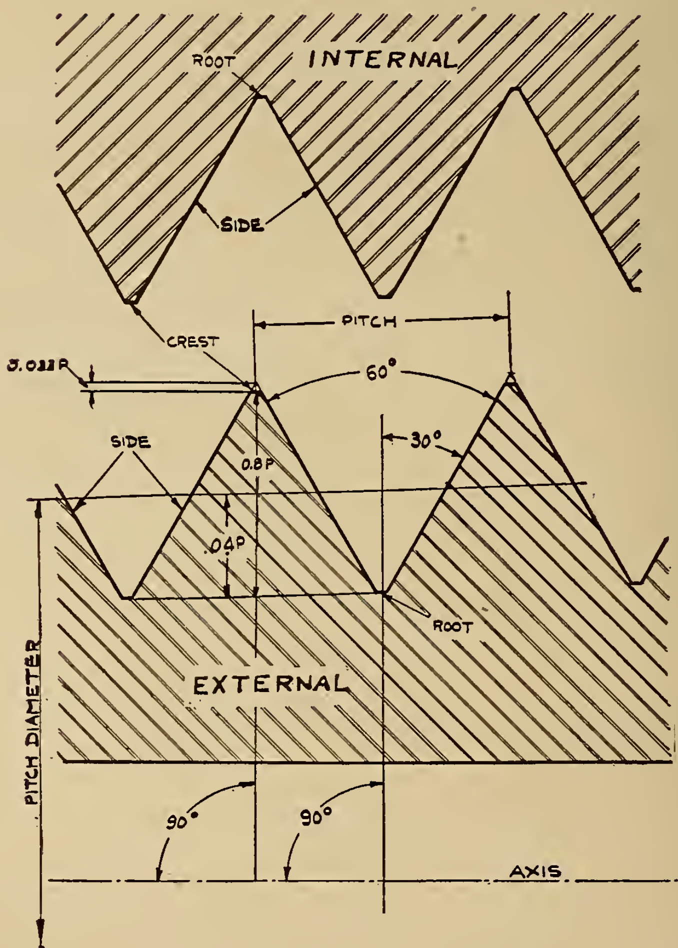
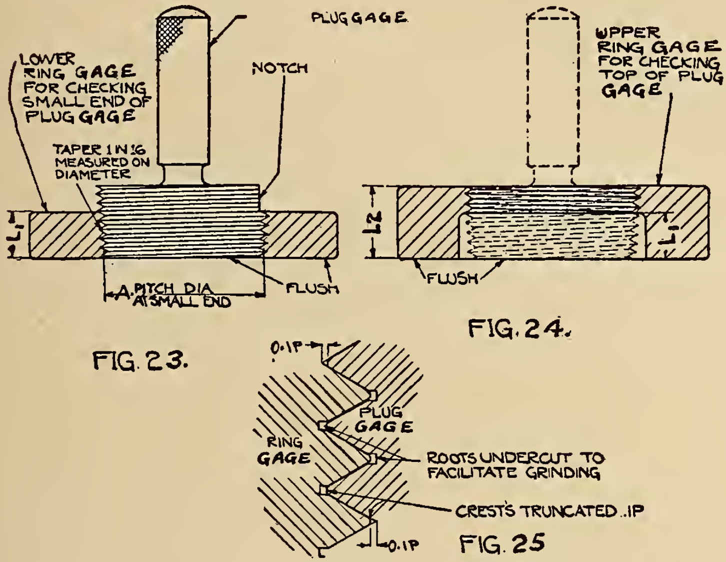
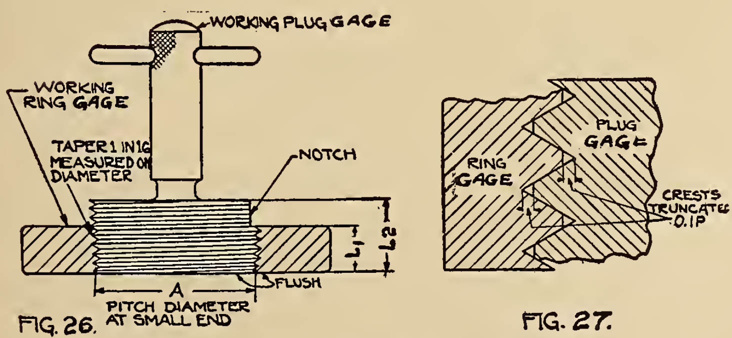


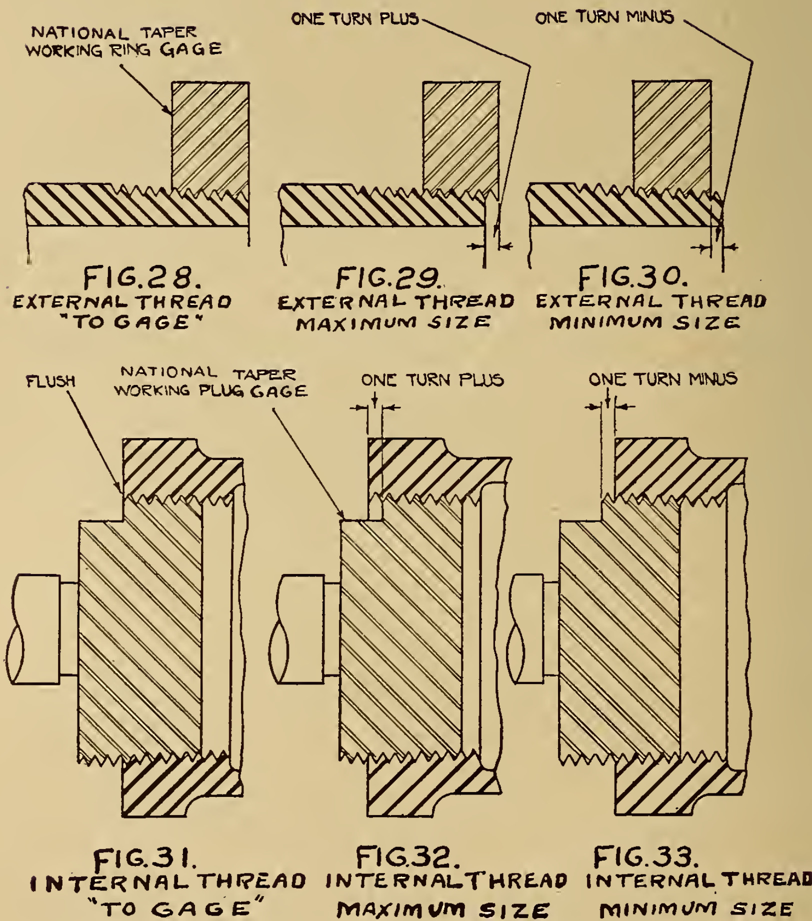
Fig. 22.—*Form of national taper pipe thread*



FIGS. 23, 24, AND 25.—*Reference gages for checking working gages*



FIGS. 26 AND 27.—*Working gages for checking product*



FIGS. 28, 29, 30, 31, 32, AND 33.—*Gages for national taper pipe threads*

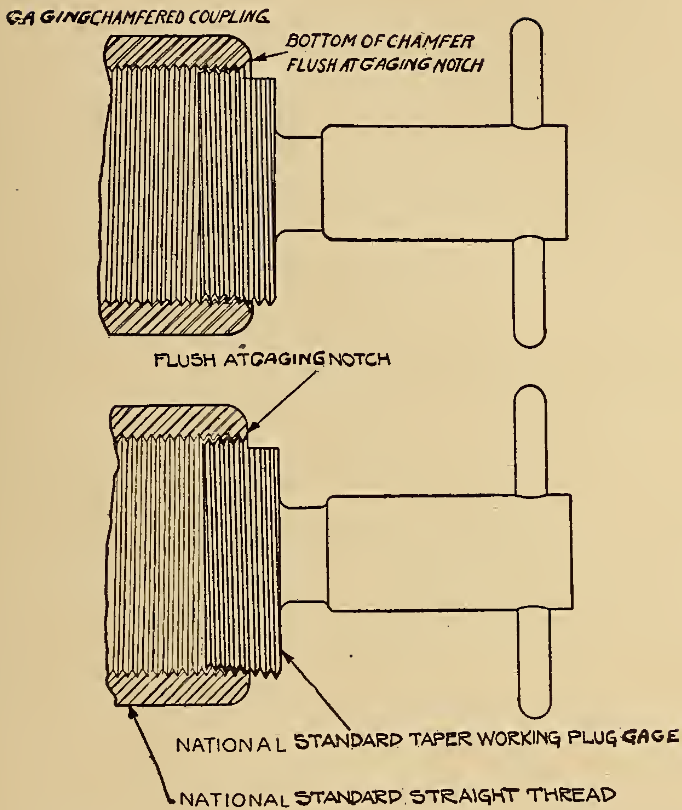


FIG. 34.—*Illustration of straight threaded coupling gaged with standard taper working plug gage*

(See Figs. 32 and 33 for tolerance. Taper four times actual)

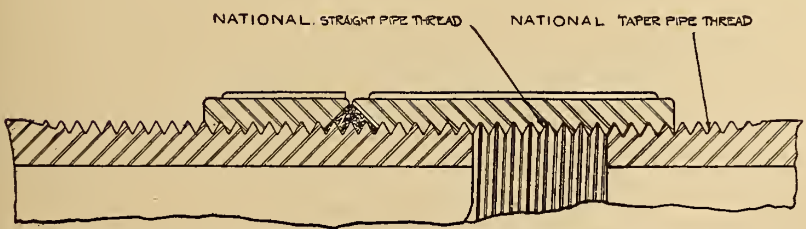


FIG. 35.—*Illustration of "long screw" joint between straight threaded coupling and taper threaded pipe*

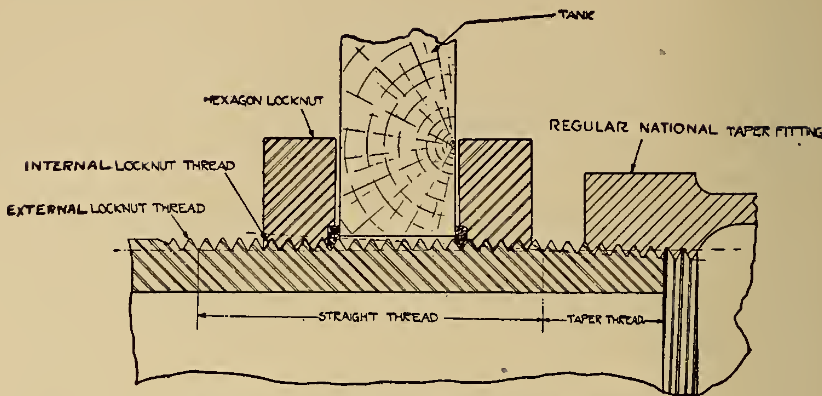
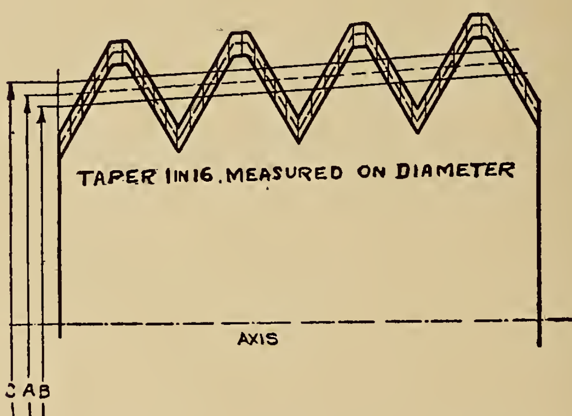


FIG. 36.—*Illustration of "tank nipple" thread*



A = Basic pitch diameter at small end of gage

B = Minimum pitch diameter at small end of gage

C = Maximum pitch diameter at small end of gage

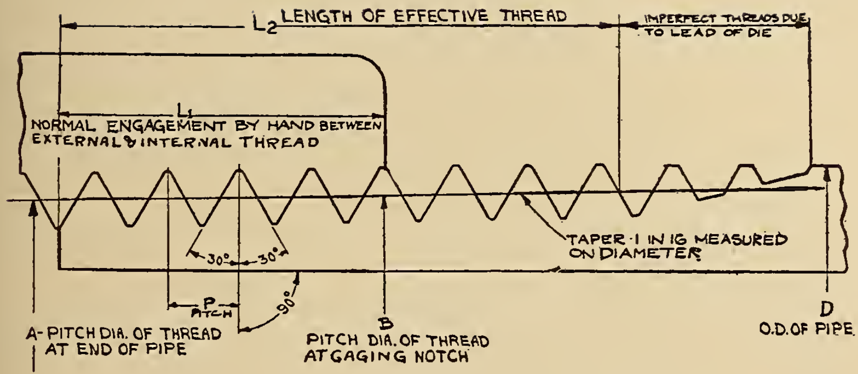
$$B = A - \left\{\begin{array}{l}\text{Column 1 from Table 26 for reference gages}\\ \text{Column 5 from Table 27 for new working gages}\end{array}\right.$$

$$C = A + \left\{\begin{array}{l}\text{Column 1 from Table 26 for reference gages}\\ \text{Column 5 from Table 27 for new working gages}\end{array}\right.$$

No point on the thread surface of the gage should be outside of the zone of tolerance indicated by the shaded portion of the illustration

The dotted line indicates the outline of a perfect gage made exactly to the basic dimensions

FIG. 37.—*Illustration of tolerance and basic dimensions of a perfect taper pipe thread gage*



$$A = D - (0.05D) + 1.1)P$$
$$B = A + 0.0625L_1$$
$$L_2 = P\ (0.8D + 6.8)$$
$$\text{Depth of thread} = 0.8P$$

FIG. 38.—*National taper pipe thread notation*

TABLE 19.—Dimensions of National Taper Pipe Threads

[For notation, see Fig. 38, p. 73.]

Nominal size		*A*		*B*		*L*₂		*L*₁		*D*		Depth of thread		Number of threads—	
Inches	mm	Inches	mm	Inches	mm	Inches	mm	Inches	mm	Inches	mm	Inch	mm	Per inch	Per 254 mm
1/8	3	0.36351	9.233	0.37476	9.519	0.2638	6.700	0.180	4.572	0.405	10.287	0.02963	0.753	27	270
1/4	6	.47739	12.126	.48989	12.443	.4018	10.206	.200	5.080	.540	13.716	.04444	1.129	18	180
3/8	10	.61201	15.545	.62701	15.926	.4078	10.358	.240	6.096	.675	17.145	.04444	1.129	18	180
1/2	13	.75843	19.264	.77843	19.772	.5337	13.556	.320	8.128	.840	21.336	.05714	1.451	14	140
3/4	19	.96768	24.579	.98886	25.117	.5457	13.861	.339	8.611	1.050	26.670	.05714	1.451	14	140
1	25	1.21363	30.826	1.23863	31.461	.6828	17.343	.400	10.160	1.315	33.401	.06956	1.767	11 1/2	115
1 1/4	32	1.55713	39.551	1.58338	40.218	.7068	17.953	.420	10.668	1.660	42.164	.06956	1.767	11 1/2	115
1 1/2	38	1.79609	45.621	1.82234	46.287	.7235	18.377	.420	10.668	1.900	48.260	.06956	1.767	11 1/2	115
2	50	2.26902	57.633	2.29627	58.235	.7565	19.215	.436	11.074	2.375	60.325	.06956	1.767	11 1/2	115
2 1/2	64	2.71953	69.076	2.76216	70.159	1.1375	28.892	.682	17.323	2.875	73.025	.10000	2.540	8	80
3	76	3.34063	84.852	3.38850	86.068	1.2000	30.480	.766	19.456	3.500	88.900	.10000	2.540	8	80
3 1/2	90	3.83750	97.473	3.88881	98.776	1.2500	31.750	.821	20.853	4.000	101.600	.10000	2.540	8	80
4	100	4.33438	110.093	4.38713	111.433	1.3000	33.020	.844	21.438	4.500	114.300	.10000	2.540	8	80
4 1/2	113	4.83125	122.714	4.88594	124.103	1.3500	34.290	.875	22.225	5.000	127.000	.10000	2.540	8	80
5	125	5.39073	136.925	5.44929	138.412	1.4063	35.720	.937	23.800	5.563	141.300	.10000	2.540	8	80
6	150	6.44609	163.731	6.50597	165.252	1.5125	38.417	.958	24.333	6.625	168.275	.10000	2.540	8	80
7	175	7.43984	188.972	7.50234	190.560	1.6125	40.957	1.000	25.400	7.625	193.675	.10000	2.540	8	80
8	200	8.43359	214.214	8.50003	215.901	1.7125	43.497	1.063	27.000	8.625	219.075	.10000	2.540	8	80
9	225	9.42734	239.455	9.49797	241.249	1.8125	46.037	1.130	28.702	9.625	244.475	.10000	2.540	8	80
10	250	10.54531	267.851	10.62094	269.772	1.9250	48.895	1.210	30.734	10.750	273.050	.10000	2.540	8	80
11	275	11.53906	293.093	11.61938	295.133	2.0250	51.435	1.285	32.639	11.750	298.450	.10000	2.540	8	80
12	300	12.53281	318.334	12.61781	320.493	2.1250	53.975	1.360	34.544	12.750	323.851	.10000	2.540	8	80
14 O. D.	350	13.77500	349.886	13.87262	352.365	2.250	57.150	1.562	39.675	14.000	355.601	.10000	2.540	8	80
15 O. D.	375	14.76875	375.127	14.87419	377.805	2.350	59.690	1.687	42.850	15.000	381.001	.10000	2.540	8	80
16 O. D.	400	15.76250	400.368	15.87575	403.245	2.450	62.230	1.812	46.025	16.000	406.401	.10000	2.540	8	80
17 O. D.	425	16.75625	425.609	16.87500	428.626	2.550	64.770	1.900	48.260	17.000	431.801	.10000	2.540	8	80
18 O. D.	450	17.75000	450.851	17.87500	454.026	2.650	67.310	2.000	50.800	18.000	457.201	.10000	2.540	8	80
20 O. D.	500	19.73750	501.333	19.87031	504.707	2.850	72.390	2.125	53.975	20.000	508.001	.10000	2.540	8	80
22 O. D.	550	21.72500	551.816	21.86562	555.388	3.050	77.470	2.250	57.150	22.000	558.801	.10000	2.540	8	80
24 O. D.	600	23.71250	602.299	23.86094	606.069	3.250	82.550	2.375	60.325	24.000	609.601	.10000	2.540	8	80
26 O. D.	650	25.70000	652.781	25.85625	656.750	3.450	87.630	2.500	63.500	26.000	660.401	.10000	2.540	8	80
28 O. D.	700	27.68750	703.264	27.85156	707.431	3.650	92.710	2.625	66.675	28.000	711.201	.10000	2.540	8	80
30 O. D.	750	29.67500	753.746	29.84687	758.112	3.850	97.790	2.750	69.850	30.000	762.001	.10000	2.540	8	80

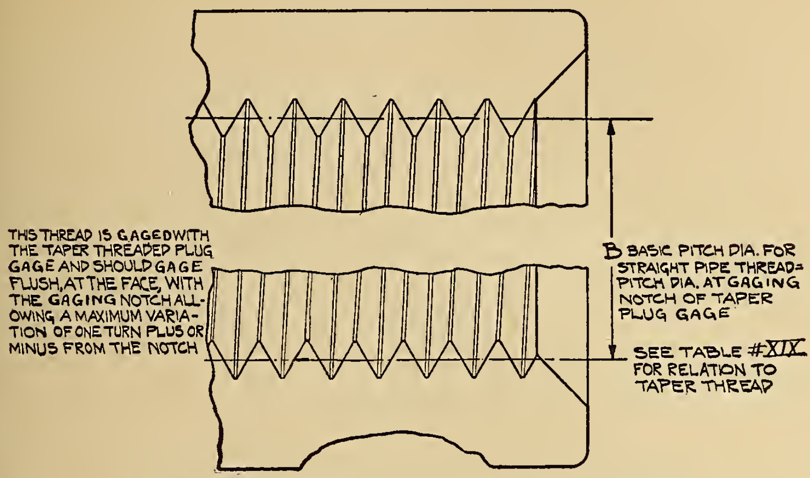


FIG. 39.—*National straight pipe thread notation (internal)*

TABLE 20.—Dimensions of National Straight Pipe Threads

Nominal size		*B*		Depth of thread		Number of threads—	
Inches	mm	Inches	mm	Inch	mm	Per inch	Per 254 mm
1/8	3	0.37476	9.519	0.02963	0.753	27	270
1/4	6	.48989	12.443	.04444	1.129	18	180
3/8	10	.62701	15.926	.04444	1.129	18	180
1/2	13	.77843	19.772	.05714	1.451	14	140
3/4	19	.98886	25.117	.05714	1.451	14	140
1	25	1.23863	31.461	.06956	1.767	11½	115
1¼	32	1.58338	40.218	.06956	1.767	11½	115
1½	38	1.82234	46.287	.06956	1.767	11½	115
2	50	2.29627	58.325	.06956	1.767	11½	115
2½	64	2.76216	70.159	.10000	2.540	8	80
3	76	3.38850	86.068	.10000	2.540	8	80
3½	90	3.88881	98.776	.10000	2.540	8	80
4	100	4.38713	111.433	.10000	2.540	8	80
4½	113	4.88594	124.103	.10000	2.540	8	80
5	125	5.44929	138.412	.10000	2.540	8	80
6	150	6.50597	165.252	.10000	2.540	8	80
7	175	7.50234	190.560	.10000	2.540	8	80
8	200	8.50003	215.901	.10000	2.540	8	80
9	225	9.49797	241.249	.10000	2.540	8	80
10	250	10.62094	269.772	.10000	2.540	8	80
11	275	11.61938	295.133	.10000	2.540	8	80
12	300	12.61781	320.493	.10000	2.540	8	80
14 O. D.	350	13.87262	352.365	.10000	2.540	8	80
15 O. D.	375	14.87419	377.805	.10000	2.540	8	80
16 O. D.	400	15.87575	403.245	.10000	2.540	8	80
17 O. D.	425	16.87500	428.626	.10000	2.540	8	80
18 O. D.	450	17.87500	454.026	.10000	2.540	8	80
20 O. D.	500	19.87031	504.707	.10000	2.540	8	80
22 O. D.	550	21.86562	555.388	.10000	2.540	8	80
24 O. D.	600	23.86094	606.069	.10000	2.540	8	80
26 O. D.	650	25.85625	656.750	.10000	2.540	8	80
28 O. D.	700	27.85156	707.431	.10000	2.540	8	80
30 O. D.	750	29.84687	758.112	.10000	2.540	8	80

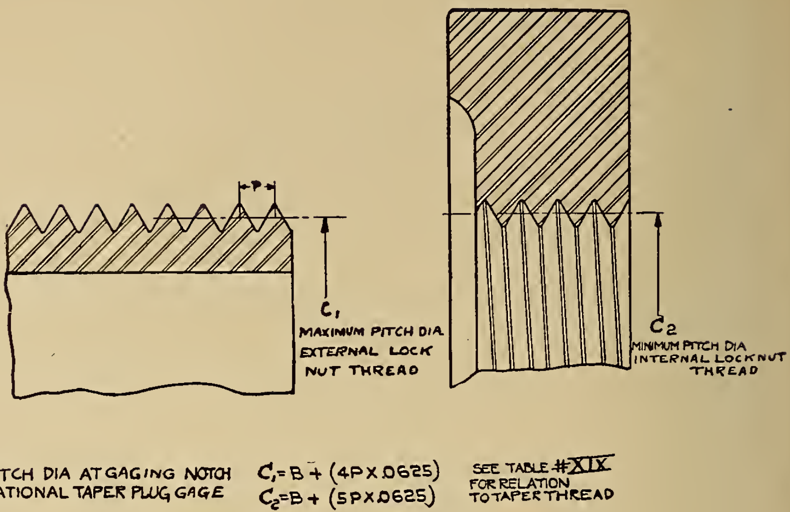


FIG. 40.—*National locknut thread notation*

TABLE 21.—Dimensions of National Locknut Threads

Nominal size		C_1		C_2		Depth of thread		Number of threads—	
Inches	mm	Inches	mm	Inches	mm	Inch	mm	Per inch	Per 254 mm
⅛	3	0.38402	9.754	0.38633	9.813	0.02963	0.753	27	270
¼	6	.50378	12.796	.50725	12.884	.04444	1.129	18	180
⅜	10	.64090	16.279	.64437	16.367	.04444	1.129	18	180
½	13	.79628	20.225	.80075	20.339	.05714	1.451	14	140
¾	19	1.00672	25.571	1.01118	25.684	.05714	1.451	14	140
1	25	1.26037	32.013	1.26580	32.151	.06956	1.767	11½	115
1¼	32	1.60512	40.770	1.61055	40.908	.06956	1.767	11½	115
1½	38	1.84407	46.839	1.84951	46.978	.06956	1.767	11½	115
2	50	2.31801	58.877	2.32344	59.015	.06956	1.767	11½	115
2½	64	2.79341	70.953	2.80122	71.151	.10000	2.540	8	80
3	76	3.41975	86.862	3.42756	87.060	.10000	2.540	8	80
3½	90	3.92006	99.570	3.92787	99.768	.10000	2.540	8	80
4	100	4.41838	112.227	4.42619	112.425	.10000	2.540	8	80
4½	113	4.91719	124.897	4.92500	125.095	.10000	2.540	8	80
5	125	5.48054	139.206	5.48836	139.405	.10000	2.540	8	80
6	150	6.53722	166.046	6.54503	166.244	.10000	2.540	8	80
7	175	7.53359	191.354	7.54141	191.552	.10000	2.540	8	80
8	200	8.53128	216.695	8.53909	216.893	.10000	2.540	8	80
9	225	9.52922	242.043	9.53703	242.241	.10000	2.540	8	80
10	250	10.65219	270.566	10.66000	270.764	.10000	2.540	8	80
11	275	11.65063	295.927	11.65844	296.125	.10000	2.540	8	80
12	300	12.64906	321.287	12.65688	321.485	.10000	2.540	8	80

TABLE 22.—Dimensions of Standard Wrought Pipe

[Material on pages 77 to 80 is not a part of the thread standard, but is reprinted as part of the Manual.]

Nominal size		Inside diameter		External diameter		Nominal thickness		Transverse areas				Length of pipe per sq. ft. of external surface	Length of pipe per sq. meter of external surface	Nominal weight per ft. threaded and coupled	Nominal weight per meter threaded and coupled
								Internal		Metal					
Inches	mm	Inches	mm	Inches	mm	Inch	mm	In^2	mm^2	In^2	mm^2	Feet	m	Pounds	kg
1/8	3	0.269	6.833	0.405	10.287	0.068	1.727	0.057	36.77	0.072	46.45	9.431	30.94	0.245	0.364
1/4	6	.364	9.246	.540	13.716	.088	2.235	.104	67.10	.125	80.64	7.073	23.20	.425	.632
3/8	10	.493	12.522	.675	17.145	.091	2.311	.191	123.23	.167	107.74	5.658	18.56	.558	.845
1/2	13	.622	15.799	.840	21.336	.109	2.769	.304	196.13	.250	161.29	4.547	14.91	.852	1.268
3/4	19	.824	20.930	1.050	26.670	.113	2.870	.533	343.87	.333	214.84	3.637	11.93	1.134	1.687
1	25	1.049	26.645	1.315	33.401	.133	3.378	.864	557.42	.494	318.71	2.904	9.53	1.684	2.506
1 1/4	32	1.380	35.052	1.660	42.164	.140	3.556	1.495	964.52	.669	431.61	2.301	7.55	2.281	3.394
1 1/2	38	1.610	40.894	1.900	48.260	.145	3.683	2.036	1313.55	.799	515.48	2.010	6.59	2.731	4.064
2	50	2.067	52.502	2.375	60.325	.154	3.912	3.355	2164.52	1.075	693.55	1.608	5.27	3.678	5.473
2 1/2	64	2.469	62.713	2.875	73.025	.203	5.156	4.788	3089.04	1.704	1099.36	1.328	4.36	5.819	8.660
3	76	3.068	77.927	3.500	88.900	.216	5.486	7.393	4769.69	2.228	1437.42	1.091	3.58	7.616	11.334
3 1/2	90	3.548	90.119	4.000	101.600	.226	5.740	9.886	6378.08	2.680	1729.03	.954	3.13	9.202	13.694
4	100	4.026	102.261	4.500	114.300	.237	6.020	12.730	8212.92	3.174	2047.74	.848	2.78	10.889	16.204
4 1/2	113	4.506	114.453	5.000	127.000	.247	6.274	15.947	10288.41	3.688	2379.35	.763	2.50	12.642	18.813
5	125	5.047	128.194	5.563	141.300	.258	6.553	20.006	12907.12	4.300	2774.20	.686	2.25	14.810	22.040
6	150	6.065	154.051	6.625	168.275	.280	7.112	28.891	18639.39	5.581	3600.65	.576	1.89	19.185	28.550
7	175	7.023	178.385	7.625	193.675	.301	7.645	38.738	24992.31	6.926	4468.39	.500	1.64	23.769	35.372
8	200	8.071	205.004	8.625	219.075	.277	7.036	51.161	33007.16	7.265	4687.10	.442	1.45	25.000	37.204
8	200	7.981	202.718	8.625	219.075	.322	8.179	50.027	32275.55	8.399	5418.72	.442	1.45	28.809	42.872
9	225	8.941	227.102	9.625	244.475	.342	8.687	62.786	40507.17	9.974	6434.85	.396	1.30	34.188	50.877
10	250	10.192	258.877	10.750	273.050	.279	7.087	81.585	52635.58	9.178	5921.30	.355	1.16	32.000	47.621
10	250	10.136	257.455	10.750	273.050	.307	7.798	80.691	52058.81	10.072	6498.08	.355	1.16	35.000	52.086
10	250	10.020	254.508	10.750	273.050	.365	9.271	78.855	50874.29	11.908	7682.59	.355	1.16	41.132	61.211
11	275	11.000	279.400	11.750	298.450	.375	9.525	95.033	61311.73	13.401	8645.82	.325	1.07	46.247	68.823
12	300	12.090	307.087	12.750	323.851	.330	8.382	114.800	74064.66	12.876	8307.11	.299	.98	45.000	66.967
12	300	12.000	304.801	12.750	323.851	.375	9.525	113.097	72965.95	14.579	9405.82	.299	.98	50.706	75.459

TABLE 23.—Dimensions of Extra Strong Wrought Pipe

Nominal size		Inside diameter		External diameter		Nominal thickness		Transverse areas: Internal		Transverse areas: Metal		Length of pipe per sq. ft. of external surface	Length of pipe per sq. meter of external surface	Nominal weight per ft. plain ends	Nominal weight per meter plain ends
Inches	mm	Inches	mm	Inches	mm	Inch	mm	Inches²	mm²	Inches²	mm²	Feet	m	Pounds	kg
1/8	3	0.215	5.461	0.405	10.287	0.095	2.413	0.036	23.22	0.093	60.00	9.431	30.94	0.314	0.467
1/4	6	.302	7.671	.540	13.716	.119	3.023	.072	46.45	.157	101.29	7.073	23.20	.535	.796
3/8	10	.423	10.744	.675	17.145	.126	3.200	.141	90.97	.217	140.00	5.658	18.56	.738	1.10
1/2	13	.546	13.868	.840	21.336	.147	3.734	.234	150.97	.320	206.45	4.547	14.92	1.087	1.62
3/4	19	.742	18.847	1.050	26.670	.154	3.912	.433	279.35	.433	279.35	3.637	11.93	1.473	2.19
1	25	.957	24.308	1.315	33.401	.179	4.547	.719	463.87	.639	412.26	2.904	9.53	2.171	3.23
1 1/4	32	1.278	32.461	1.660	42.164	.191	4.851	1.283	827.74	.881	568.39	2.301	7.55	2.996	4.46
1 1/2	38	1.500	38.100	1.900	48.260	.200	5.080	1.767	1140.00	1.068	689.03	2.010	6.59	3.631	5.40
2	50	1.939	49.251	2.375	60.325	.218	5.537	2.953	1905.16	1.477	952.91	1.608	5.27	5.022	7.47
2 1/2	64	2.323	59.004	2.875	73.025	.276	7.010	4.238	2734.20	2.254	1454.20	1.328	4.36	7.661	11.40
3	76	2.900	73.660	3.500	88.900	.300	7.620	6.605	4261.30	3.016	1945.81	1.091	3.58	10.252	15.26
3 1/2	90	3 364	85.446	4.000	101.600	.318	8.077	8.888	5734.20	3.678	2372.91	.954	3.13	12.505	18.61
4	100	3.826	97.180	4.500	114.300	.337	8.560	11.497	7417.43	4.407	2843.23	.848	2.78	14.983	22.30
4 1/2	113	4.290	108.966	5.000	127.000	.355	9.017	14.455	9325.82	5.180	3341.94	.763	2.50	17.611	26.21
5	125	4.813	122.250	5.563	141.300	.375	9.525	18.194	11738.09	6.112	3943.23	.686	2.25	20.778	30.92
6	150	5.761	146.330	6.625	168.275	.432	10.973	26.067	16817.45	8.405	5422.59	.576	1.89	28.573	42.52
7	175	6.625	168.275	7.625	193.675	.500	12.700	34.472	22240.04	11.192	7220.66	.500	1.64	38.048	56.62
8	200	7.625	193.675	8.625	219.075	.500	12.700	45.663	29460.06	12.763	8234.21	.442	1.45	43.388	64.57
9	225	8.625	219.075	9.625	244.475	.500	12.700	58.426	37694.27	14.334	9247.76	.396	1.30	48.728	72.51
10	250	9.750	247.650	10.750	273.050	.500	12.700	74.662	48169.12	16.101	10387.76	.355	1.16	54.735	81.45
11	275	10.750	273.050	11.750	298.450	.500	12.700	90.763	58556.89	17.671	11400.67	.325	1.07	60.075	89.40
12	300	11.750	298.450	12.750	323.851	.500	12.700	108.434	69957.55	19.242	12414.22	.299	.98	65.415	97.35

TABLE 24.—Dimensions of Double Extra Strong Wrought Pipe

Nominal size		Inside diameter		External diameter		Nominal thickness		Transverse areas				Length of pipe per sq. ft. of external surface	Length of pipe per sq. meter of external surface	Nominal weight per ft. plain ends	Nominal weight per meter plain ends
								Internal		Metal					
Inches	mm	Inches	mm	Inches	mm	Inch	mm	Inches ^{2}	mm ^{2}	Inches ^{2}	mm ^{2}	Feet	m	Pounds	kg
½	13	0.252	6.401	0.840	21.336	0.294	7.468	0.050	32.26	0.504	325.16	4.547	14.92	1.714	2.551
¾	19	.434	11.024	1.050	26.670	.308	7.823	.148	95.48	.718	463.23	3.637	11.93	2.440	3.631
1	25	.599	15.215	1.315	33.401	.358	9.093	.282	181.93	1.076	694.19	2.904	9.53	3.659	5.445
1¼	32	.896	22.758	1.660	42.164	.382	9.703	.630	406.45	1.534	989.68	2.301	7.55	5.214	7.759
1½	38	1.100	27.940	1.900	48.260	.400	10.160	.950	612.90	1.885	1216.13	2.010	6.59	6.408	9.536
2	50	1.503	38.176	2.375	60.325	.436	11.074	1.774	1144.52	2.656	1713.55	1.608	5.27	9.029	13.436
2½	64	1.771	44.983	2.875	73.025	.552	14.021	2.464	1589.68	4.028	2598.71	1.328	4.36	13.695	20.380
3	76	2.300	58.420	3.500	88.900	.600	15.240	4.155	2680.65	5.466	3526.46	1.091	3.58	18.583	27.654
3½	90	2.728	69.291	4.000	101.600	.636	16.154	5.845	3770.97	6.721	4336.14	.954	3.13	22.850	34.004
4	100	3.152	80.061	4.500	114.300	.674	17.120	7.803	5034.20	8.101	5226.46	.848	2.78	27.541	40.985
4½	113	3.580	90.932	5.000	127.000	.710	18.034	10.066	6494.21	9.569	6173.56	.763	2.50	32.530	48.410
5	125	4.063	103.200	5.563	141.300	.750	19.050	12.966	8365.18	11.340	7316.14	.686	2.25	38.552	57.371
6	150	4.897	124.384	6.625	168.275	.864	21.946	18.835	12151.64	15.637	10088.41	.576	1.89	53.160	79.110
7	175	5.875	149.225	7.625	193.675	.875	22.225	27.109	17489.71	18.555	11970.99	.500	1.64	63.079	93.872
8	200	6.875	174.625	8.625	219.075	.875	22.225	37.122	23949.72	21.304	13744.54	.442	1.45	72.424	107.778

TABLE 25.—Large O. D. Pipe

Nominal size		Outside diameter		Inside diameter																	
				¼ inch thick	6.4 mm thick	5/16 inch thick	7.9 mm thick	⅜ inch thick	9.5 mm thick	7/16 inch thick	11.1 mm thick	½ inch thick	12.7 mm thick	9/16 inch thick	14.3 mm thick	⅝ inch thick	15.9 mm thick	¾ inch thick	19.0 mm thick	1 inch thick	25.4 mm thick
Inches	mm	Inches	mm	Inches	mm	Inches	mm	Inches	mm	Inches	mm	Inches	mm	Inches	mm	Inches	mm	Inches	mm	Inches	mm
14	350	14	355.6	13½	342.9	13⅜	339.7	13¼	336.6	13⅛	333.4	13	330.2	12⅞	327.0	12¾	323.8	12½	317.5	12	304.8
15	375	15	381.0	14½	368.3	14⅜	365.1	14¼	362.0	14⅛	358.8	14	355.6	13⅞	352.4	13¾	349.2	13½	342.9	13	330.2
16	400	16	406.4	15½	393.7	15⅜	390.5	15¼	387.4	15⅛	384.2	15	381.0	14⅞	377.8	14¾	374.6	14½	368.3	14	355.6
17	425	17	431.8	16½	419.1	16⅜	415.9	16¼	412.8	16⅛	409.6	16	406.4	15⅞	403.2	15¾	400.0	15½	393.7	15	381.0
18	450	18	457.2	17½	444.5	17⅜	441.3	17¼	438.2	17⅛	435.0	17	431.8	16⅞	428.6	16¾	425.4	16½	419.1	16	406.4
20	500	20	508.0	....	....	19⅜	492.0	19¼	489.0	19⅛	485.8	19	482.6	18⅞	479.4	18¾	476.2	18½	469.9	18	457.2
22	550	22	558.8	....	....	21⅜	542.9	21¼	539.8	21⅛	536.6	21	533.4	20⅞	530.2	20¾	527.0	20½	520.7	....	....
24	600	24	609.6	....	....	....	....	23¼	590.6	23⅛	587.4	23	584.2	22⅞	581.0	22¾	577.8	22½	571.5	....	....
26	650	26	660.4	....	....	....	....	25¼	641.4	25⅛	638.2	25	635.0	24⅞	631.8	24¾	628.6	24½	622.3	....	....
28	700	28	711.2	....	....	....	....	....	....	27⅛	689.0	27	685.8	26⅞	682.6	26¾	679.4	26½	673.1	....	....
30	750	30	762.0	....	....	....	....	....	....	29⅛	739.8	29	736.6	28⅞	733.4	28¾	730.2	28½	723.9	....	....

TABLE 26.—Tolerances for Reference Gages

Nominal size		1 (Total cumulative tolerance on diameter. (See Fig. 37))		2 (Equivalent longitudinal variation (16 X Col. 1))		3 Equivalent angular variation expressed as decimal part of one turn	a4	
Inches	mm	Inch	mm	Inch	mm		Inch	mm
1/8	3	0.00020	0.0050	0.0032	0.081	0.086	0.0068	0.173
1/4	6	.00022	.0056	.0035	.089	.063	.0074	.188
3/8	10	.00024	.0061	.0038	.097	.068	.0080	.203
1/2	13	.00026	.0066	.0042	.107	.059	.0088	.224
3/4	19	.00028	.0071	.0045	.114	.063	.0094	.239
1	25	.00030	.0076	.0048	.122	.055	.0100	.254
1 1/4	32	.00032	.0081	.0051	.130	.059	.0106	.269
1 1/2	38	.00034	.0086	.0054	.137	.062	.0112	.284
2	50	.00036	.0091	.0058	.147	.067	.0120	.305
2 1/2	64	.00038	.0097	.0061	.155	.050	.0126	.320
3	76	.00038	.0097	.0061	.155	.050	.0126	.320
3 1/2	90	.00041	0104	.0066	.168	.053	.0136	.345
4	100	.00043	.0109	.0069	.175	.055	.0142	.361
4 1/2	113	.00045	.0114	.0072	.183	.058	.0148	.376
5	125	.00047	.0119	.0075	.191	.060	.0154	.391
6	150	.00051	.0130	.0082	.208	.065	.0168	.427
7	175	.00055	.0140	.0088	.224	.070	.0180	.457
8	200	.00059	.0150	.0094	.239	.075	.0192	.488
9	225	.00063	.0160	.0101	.257	.080	.0206	.523
10	250	.00066	.0168	.0106	.269	.085	.0216	.549
12	300	.00074	.0188	.0118	.300	.095	.0240	.610
14	350	.00082	.0208	.0131	.333	.105	.0266	.676
16	400	.00090	.0229	.0144	.366	.115	.0292	.742
18	450	.00098	.0249	.0157	.399	.125	.0318	.808
20	500	.00106	.0269	.0170	.432	.135	.0344	.874
22	550	.00113	.0287	.0181	.460	.145	.0366	.930
24	600	.00121	.0307	.0194	.493	.155	.0392	.996
26	650	.00129	.0328	.0206	.523	.165	.0416	1.057
28	700	.00137	.0348	.0219	.556	.175	.0442	1.123
30	750	.00144	.0366	.0230	.584	.185	.0464	1.179

[a] Maximum amount it is possible for plug and ring gages to vary from being flush at small end or at gaging notch when screwed together tight by hand. (2 times Column 2 + 0.0004".)

TABLE 27.—Tolerances for Working Gages

Nominal size		5 Total cumulative tolerance on diameter. (See Fig. 37)		6 Equivalent longitudinal variation. (16 times Column 5)		[a] 7	[b] 8		[c] 9	
Inches	mm	Inch	mm	Inch	mm		Inch	mm	Inch	mm
⅛	3	0.00040	0.0102	0.0064	0.163	0.172	0.0138	0.351	0.0103	0.262
¼	6	.00044	.0112	.0070	.178	.126	.0150	.381	.0112	.284
⅜	10	.00048	.0122	.0077	.196	.136	.0164	.417	.0122	.310
½	13	.00052	.0132	.0083	.211	.118	.0176	.447	.0132	.335
¾	19	.00056	.0142	.0090	.229	.126	.0190	.483	.0142	.361
1	25	.00060	.0152	.0096	.244	.110	.0202	.513	.0151	.384
1¼	32	.00064	.0163	.0102	.259	.118	.0214	.544	.0160	.406
1½	38	.00068	.0173	.0109	.277	.124	.0228	.579	.0170	.432
2	50	.00072	.0183	.0115	.292	.134	.0240	.610	.0180	.457
2½	64	.00076	.0193	.0122	310	.100	.0254	.645	.0190	.483
3	76	.00076	.0193	.0122	.310	.100	.0254	.645	.0190	.483
3½	90	.00082	.0208	.0131	.333	.105	.0272	.691	.0204	.518
4	100	.00086	.0218	.0138	.351	.110	.0286	.726	.0214	.544
4½	113	.00090	.0229	.0144	.366	.115	.0298	.757	.0223	.566
5	125	.00094	.0239	.0150	.381	.120	.0310	.787	.0232	.589
6	150	.00102	.0260	.0163	.414	.130	.0336	.853	.0252	.640
7	175	.00110	.0330	.0176	.447	.140	.0362	.919	.0271	.688
8	200	.00118	.0348	.0189	.480	.150	.0388	.986	.0290	.737
9	225	.00126	.0370	.0202	.513	.160	.0414	1.052	.0310	.787
10	250	.00132	.0432	.0211	.536	.170	.0432	1.097	.0324	.823
12	300	.00148	.0472	.0237	.602	.190	.0484	1.229	.0362	.919
14	350	.00164	.0513	.0262	.665	.210	.0534	1.356	.0400	1.016
16	400	.00180	.0554	.0288	.732	.230	.0586	1.488	.0439.	1.115
18	450	.00196	.0594	.0314	.798	.250	.0638	1.621	.0478	1.214
20	500	.00212	.0683	.0339	.861	.270	.0688	1.748	.0516	1.311
22	550	.00226	.0719	.0362	.919	.290	.0734	1.864	.0550	1.397
24	600	.00242	.0759	.0387	.983	.310	.0784	1.991	.0588	1.494
26	650	.00258	.0800	.0413	1.049	.330	.0836	2.123	.0626	1.590
28	700	.00274	.0841	.0438	1.113	.350	.0886	2.250	.0664	1.687
30	750	.00288	.0732	.0461	1.171	.370	.0932	2.367	.0698	1.773

[a] Equivalent angular variation expressed as a decimal part of one turn.

[b] Maximum amount it is possible for new working plug and ring gages which come within the specified tolerances to vary from being flush at the small end or at the gaging notch when screwed together tight by hand. (2 times Column 6+0.0010.)

[c] Maximum amount it is possible for new working plug or ring gages which come within specified tolerances to vary from being flush at the small end or at the gaging notch when screwed on reference gage tight by hand. $\frac{(\text{Column } 4+\text{Column } 8.)}{2}$

TABLE 28.—Corrections in Diameter for Errors in Angle

A = Error in half included angle of thread expressed in minutes

$$\text{Correction in diameter} = \frac{1.332P \sin A}{\sin\ (60° + A)}$$

A	8 threads		11½ threads		14 threads		18 threads		27 threads	
	Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm
1′	0.000056	0.0014	0.000039	0.0010	0.000032	0.0008	0.000025	0.0006	0.000017	0.0004
2′	.000112	.0028	.000078	.0020	.000064	.0016	.000050	.0013	.000033	.0008
3′	.000168	.0043	.000117	.0030	.000096	.0024	.000075	.0019	.000050	.0013
4′	.000224	.0057	.000156	.0040	.000128	.0033	.000099	.0025	.000066	.0017
5′	.000279	.0071	.000194	.0049	.000160	.0041	.000124	.0031	.000083	.0021
6′	.000335	.0085	.000233	.0059	.000192	.0049	.000149	.0038	.000099	.0025
7′	.000391	.0099	.000272	.0069	.000223	.0057	.000174	.0044	.000116	.0029
8′	.000447	.0114	.000311	.0079	.000255	.0065	.000199	.0051	.000132	.0034
9′	.000503	.0128	.000350	.0089	.000287	.0073	.000223	.0057	.000149	.0038
10′	.000558	.0142	.000388	.0099	.000319	.0081	.000248	.0063	.000165	.0042
11′	.000614	.0156	.000427	.0108	.000351	.0089	.000273	.0069	.000182	.0046
12′	.000670	.0170	.000466	.0118	.000383	.0097	.000298	.0076	.000198	.0050
13′	.000725	.0184	.000505	.0128	.000415	.0105	.000322	.0082	.000215	.0055
14′	.000781	.0198	.000543	.0138	.000446	.0113	.000347	.0088	.000231	.0059
15′	.000837	.0213	.000582	.0148	.000478	.0121	.000372	.0095	.000248	.0063
16′	.000892	.0227	.000621	.0158	.000510	.0130	.000397	.0101	.000264	.0067
17′	.000948	.0241	.000660	.0168	.000542	.0138	.000421	.0107	.000281	.0071
18′	.001004	.0255	.000698	.0177	.000574	.0146	.000446	.0113	.000297	.0075
19′	.001059	.0269	.000737	.0187	.000605	.0154	.000471	.0120	.000314	.0080
20′	.001115	.0283	.000776	.0197	.000637	.0162	.000495	.0126	.000330	.0084
21′	.001170	.0297	.000814	.0207	.000669	.0170	.000520	.0132	.000347	.0088
22′	.001226	.0311	.000853	.0217	.000700	.0178	.000545	.0138	.000363	.0092
23′	.001281	.0325	.000891	.0226	.000732	.0186	.000570	.0145	.000380	.0097
24′	.001337	.0340	.000930	.0236	.000764	.0194	.000594	.0151	.000396	.0101
25′	.001392	.0354	.000969	.0246	.000796	.0202	.000619	.0157	.000413	.0105
26′	.001448	.0368	.001007	.0256	.000827	.0210	.000643	.0163	.000429	.0109
27′	.001503	.0382	.001046	.0266	.000859	.0218	.000668	.0170	.000445	.0113
28′	.001559	.0396	.001084	.0275	.000891	.0226	.000693	.0176	.000462	.0117
29′	.001614	.0410	.001123	.0285	.000922	.0234	.000717	.0182	.000478	.0121
30′	.001669	.0424	.001161	.0295	.000954	.0242	.000742	.0188	.000495	.0126
45′	.002498	.0634	.001738	.0441	.001427	.0362	.001110	.0282	.000740	.0188
60′	.003322	.0844	.002311	.0587	.001899	.0482	.001477	.0375	.000984	.0250

TABLE 29.—Correction in Diameter For Errors in Lead

[Correction in Diameter= − 1.732 E. E=error in lead.]

Error in lead	Correction in diameter									
	0.00000	0.00001	0.00002	0.00003	0.00004	0.00005	0.00006	0.00007	0.00008	0.00009
0.00000	0.00000	0.00002	0.00003	0.00005	0.00007	0.00009	0.00010	0.00012	0.00014	0.00016
.00010	.00017	.00019	.00021	.00023	.00024	.00026	.00028	.00029	.00031	.00033
.00020	.00035	.00036	.00038	.00040	.00042	.00043	.00045	.00047	.00048	.00050
.00030	.00052	.00054	.00055	.00057	.00059	.00061	.00062	.00064	.00066	.00068
.00040	.00069	.00071	.00073	.00074	.00076	.00078	.00080	.00081	.00083	.00085
.00050	.00087	.00088	.00090	.00092	.00094	.00095	.00097	.00099	.00100	.00102
.00060	.00104	.00106	.00107	.00109	.00111	.00113	.00114	.00116	.00118	.00120
.00070	.00121	.00123	.00125	.00126	.00128	.00130	.00132	.00133	.00135	.00137
.00080	.00139	.00140	.00142	.00144	.00145	.00147	.00149	.00151	.00152	.00154
.00090	.00156	.00158	.00159	.00161	.00163	.00165	.00166	.00168	.00170	.00171
.00100	.00173	.00175	.00177	.00178	.00180	.00182	.00184	.00185	.00187	.00189
.00110	.00191	.00192	.00194	.00196	.00197	.00199	.00201	.00203	.00204	.00206
.00120	.00208	.00210	.00211	.00213	.00215	.00217	.00218	.00220	.00222	.00223
.00130	.00225	.00227	.00229	.00230	.00232	.00234	.00236	00237	.00239	.00241
.00140	.00242	.00244	.00246	.00248	.00249	.00251	.00253	.00255	.00256	.00258
.00150	.00260	.00262	.00263	.00265	.00267	.00268	.00270	.00272	.00274	.00275
.00160	.00277	.00279	.00281	.00282	.00284	.00286	.00288	.00289	.00291	.00293
.00170	.00294	.00296	.00298	.00300	.00301	.00303	.00305	.00307	.00308	.00310
.00180	.00312	.00313	.00315	.00317	.00319	.00340	.00322	.00324	.00326	.00327
.00190	.00329	.00331	.00333	.00334	.00336	.00338	.00339	.00341	.00343	.00345
.00200	.00346	.00348	.00350	.00352	.00353	.00355	.00357	.00359	.00360	.00362

VIII. FUTURE WORK OF COMMISSION

The problems of standardization so far considered by the commission have been those of most pressing importance to manufacturers and users of screw-thread products. Problems of less importance have necessarily been postponed until such time as they can be given proper consideration.

It is the intention of the commission, after issuing the present tentative report, to continue the work of gathering information in regard to special problems still to be considered. In this connection, there is outlined in the following paragraphs some of the standardization work that should be done.

1. THREADS REQUIRING STANDARDIZATION

The following list includes the more important screw threads which require standardization:

(*a*) Threads cut on brass tubing.
(*b*) Instrument threads.
(*c*) Acme, square, buttress, and other special threads.

2. STANDARDIZATION OF PRODUCTS CLOSELY ALLIED TO THE MANUFACTURE OF SCREW THREADS

In addition to the standardization of various thread systems, it would be of great advantage to American manufacturers to have established standards for stock tools and other appliances used in the production of screw threads, such as are mentioned in the following list:

(*a*) Taps.
(*b*) Dies.
(*c*) Sizes of bar stock for producing cut threads.
(*d*) Sizes of bar stock for producing rolled threads.
(*e*) Dimensions of bolt heads and nuts.
(*f*) Standardization of sheet-metal and wire-gage sizes.
(*g*) Standardization of tap-drill sizes.

3. POSSIBILITY OF INTERNATIONAL STANDARDIZATION

The recent war has demonstrated the need of interchangeability of articles manufactured in this country with those manufactured in foreign countries, and it is known that manufacturers and authorities of Great Britain, France, and other foreign countries are awake to the situation and, in fact, have already taken steps toward the international standardization of screw threads and other manufactured articles. Furthermore, international standardization is of great importance in connection with the development of foreign trade.

In July, 1919, the commission sent to Europe a delegation of its members to confer with British and French engineering standards organizations, and while no definite agreements were reached in regard to international standardization of screw threads, it was apparent in both France and England that the engineers and manufacturers in these countries are anxious to cooperate with the United States in this work. The time is very opportune for accomplishments along this line, and it is the opinion of the commission that, as a result of the war, it should be possible to reach an agreement on an international standard thread. Such an international standard should be established by giving consideration to the predominating sizes and standards used in manufactured products, as well as to the possibilities of providing a means for producing this international screw thread by the use of either the English or the metric system of measurement.

S. W. Stratton,
(*Director, Bureau of Standards*)
Chairman, National Screw Thread Commission.

Washington, June 26, 1920.

IX. APPENDIXES

APPENDIX 1. ORIGIN OF THE COMMISSION

(*a*) Historical.—The standardization of screw threads has been a subject of vital interest to manufacturers since the efforts of Sir Joseph Whitworth in 1841 and of William Sellers in 1864. The efforts of Sir Joseph Whitworth in ascertaining shop practice in the manufacture of screw threads resulted in the standardization and adoption of the Whitworth Thread System, which found extensive use in England. When William Sellers promulgated through the Franklin Institute the Sellers Thread, which resulted in the extensive use of the present United States Standard series, a great achievement of direct benefit to American manufacturers was realized.

In recent years numerous organizations have carried forward the standardization of screw threads. The American Society of Mechanical Engineers, the Society of Automotive Engineers, the Bureau of Standards, and prominent manufacturers of specialized thread products, have been the chief influences in standardization of screw threads in this country. In England the standardization of screw threads has been carried forward by the British Engineering Standards Association, an organization formed in 1901.

The development in the manufacture of machine tools, automobiles, agricultural implements, typewriters, sewing machines, and other standard manufacturing products has made apparent the need for standardized and interchangeable screw threads and threaded parts. In addition to the need of standardization, which grew by virtue of improvements in general manufacturing practices, the difficulties encountered in the program for procuring munitions in the recent war demonstrated the vital necessity of standardized screw threads. Through the efforts of the engineering societies, the Bureau of Standards, and prominent manufacturers of screw-thread products a petition was presented to Congress, requesting the appointment of a commission to investigate and promulgate standards of screw threads to be adopted by manufacturing plants under the control of the Army and Navy, and for adoption and use by the public.

(*b*) Commission Authorized by Congress.—As a result of this action, the National Screw Thread Commission was authorized by the following act of Congress, approved July 18, 1918. (Public Document No. 201, 65th Cong., H. R. 10852.)

AN ACT To provide for the appointment of a commission to standardize screw threads.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That a commission is hereby created, to be known as the Commission for the Standardization of Screw Threads, hereinafter referred to as the commission, which shall be composed of nine commissioners, one of whom shall be the Director of the Bureau of Standards, who shall be chairman of the commission; two commissioned officers of the Army, to be appointed by the Secretary of War; two commissioned officers of the Navy, to be appointed by the Secretary of the Navy; and four to be appointed by the Secretary of Commerce, two of whom shall be chosen from nominations made by the American Society of Mechanical Engineers and two from nominations made by the Society of Automotive Engineers.

Sec. 2. That it shall be the duty of said commission to ascertain and establish standards for screw threads, which shall be submitted to the Secretary of War, the Secretary of the Navy, and the Secretary of Commerce for their acceptance and approval. Such standards, when thus accepted and approved, shall be adopted and used in the several manufacturing plants under the control of the War and Navy Departments, and, so far as practicable, in all specifications for screw threads in proposals for manufactured articles, parts, or materials to be used under the direction of these departments.

Sec. 3. That the Secretary of Commerce shall promulgate such standards for use by the public and cause the same to be published as a public document.

Sec. 4. That the commission shall serve without compensation, but nothing herein shall be held to affect the pay of the commissioners appointed from the Army and Navy or of the Director of the Bureau of Standards.

SEC. 5. That the commission may adopt rules and regulations in regard to its procedure and the conduct of its business.

SEC. 6. That the commission shall cease and terminate at the end of six months from date the of its appointment.

Approved, July 18, 1918.

(*c*) LIFE OF COMMISSION EXTENDED BY CONGRESS.—Prior to the expiration of the original term of six months for which the commission was appointed, it became apparent that it would be impossible to complete in a satisfactory manner the work outlined by the commission. An extension of time was therefore asked by the commission and granted by Congress in accordance with the following act: (Public No. 324, 65th Cong. H. R. 15495.)

AN ACT To amend an Act to provide for the appointment of a commisson to standardize screw threads.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Act providing for the appointment of a commission to standardize screw threads, approved July eighteenth, nineteen hundred and eighteen, be, and the same is hereby, amended so that it will read:

"That a commission is hereby created, to be known as the Commission for the Standardization of Screw Threads, hereinafter referred to as the commission, which shall be composed of nine commissioners; one of whom shall be the Director of the Bureau of Standards, who shall be chairman of the commission; two representatives of the Army, to be appointed by the Secretary of War; two representatives of the Navy, to be appointed by the Secretary of the Navy; and four to be appointed by the Secretary of Commerce, two of whom shall be chosen from nominations made by the American Society of Mechanical Engineers and two from nominations made by the Society of Automotive Engineers.

"SEC. 2. That it shall be the duty of said commission to ascertain and establish standards for screw threads, which shall be submitted to the Secretary of War, the Secretary of the Navy, and the Secretary of Commerce for their acceptance and approval. Such standards, when thus accepted and approved, shall be adopted and used in the several manufacturing plants under the control of the War and Navy Departments, and, so far as pratcicable, in all specifications for screw threads in proposals for manufactured articles, parts, or materials to be used under the direction of these departments.

"SEC. 3. That the Secretary of Commerce shall promulgate such standards for use by the public and cause the same to be published as a public document.

"SEC. 4. That the commission shall serve without compensation, but nothing herein shall be held to affect the pay of the commissioners appointed from the Army and Navy or of the Director of the Bureau of Standards.

"SEC. 5. That the commission may adopt rules and regulations in regard to its procedure and the conduct of its business.

"SEC. 6. That the commission shall cease and terminate at the end of one year and six months from the date of its original appointment."

Approved, March 3, 1919.

(*d*) LIFE OF COMMISSION AGAIN EXTENDED BY CONGRESS.—Recognizing the impossibility of perfecting a report of this character in the first issue, and realizing the importance of providing an opportunity for making necessary changes, Congress extended the life of the commission for an additional term of two years by the following joint resolution: (Public Resolution, No. 34, 66th Cong. H. J. Res. 299.)

JOINT RESOLUTION Extending the term of the National Screw Thread Commission for a period of two years from March 21, 1920.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the term of the National Screw Thread Commission, created by an Act approved July 18, 1918, as amended by an Act approved March 3, 1919, be, and the same is hereby, extended for an additional period of two years from March 21, 1920.

Approved, March 23, 1920.

APPENDIX 2. ORGANIZATION OF THE COMMISSION

(*a*) PRELIMINARY MEETING.—As soon as nominees were selected by the various organizations to be represented in the Commission, a preliminary meeting was called at Washington, D. C., on September 12, 1918, by Dr. S. W. Stratton, Director of the Bureau of Standards, and chairman of the commission. At this meeting the organization of the commission was planned in order that work could be started as soon as formal appointments of the various members of the commission were made. The various commissioners were formally appointed under date of September 21, 1918.

(*b*) MEMBERS.—In accordance with the act, the following members were appointed.

Appointed by the Secretary of Commerce:

Chairman:

Dr. S. W. Stratton, Director of Bureau of Standards, Washington, D. C.

On nomination by American Society of Mechanical Engineers:

James Hartness.

F. O. Wells.

On nomination by Society of Automotive Engineers:

H. T. Herr.

E. H. Ehrman.

Appointed by the Secretary of War:

E. C. Peck, Lieut. Col. Ordnance, U. S. A.

O. B. Zimmerman, Major of Engineers, U. S. A.

Appointed by the Secretary of the Navy:

E. J. Marquart, Commander, U. S. N., Bureau of Ordnance.

S. M. Robinson, Commander, U. S. N., Bureau of Steam Engineering.

(*c*) OFFICERS.—The following officers were elected by the commission.

Lieut. Col. E. C. Peck, vice chairman for meetings held in Washington.

James Hartness, vice chairman for meetings held outside of Washington.

H. L. Van Keuren, executive secretary.

H. W. Bearce, general secretary.

Robert Lacy, 1st Lieut. of Engineers, U. S. A., assistant secretary.

A. W. Coombs, stenographic reporter.

(*d*) COMMITTEES.—The commission resolved itself into the following subcommittees, with authority to call to their aid one or more experts for counsel. These subcommittees were responsible for compiling and auditing data pertaining to the subject of their committee and for compiling reports for presentation to the commission as a whole, for the action of the commission.

Pitches, systems, and form of thread	F. O. Wells, chairman. Commander S. M. Robinson. E. H. Ehrman. H. W. Bearce, secretary.
Classification and tolerances	Lieut. Col. E. C. Peck, chairman. James Hartness. E. H. Ehrman. H. L. Van Keuren, secretary.
Terminology	F. O. Wells, chairman. Commander E. J. Marquart. Maj. O. B. Zimmerman. Lieut. Robert Lacy, secretary.
Gages and methods of test	James Hartness, chairman. Lieut. Col. E. C. Peck. Commander E. J. Marquart. H. L. Van Keuren, secretary.
Order of business	James Hartness, chairman. Lieut. Col. E. C. Peck. F. O. Wells.
Research	E. H. Ehrman, chairman. Maj. O. B. Zimmerman. Commander S. M. Robinson.

On May 23, 1919, Capt. John O. Johnson was appointed by the Secretary of War to succeed Maj. O. B. Zimmerman. On July 14, 1919, Commander N. H. Wright was appointed by the Secretary of the Navy to succeed Commander S. M. Robinson, and on October 7, 1919, Commander L. M. McNair was appointed by the Secretary of the Navy to succeed Commander E. J. Marquart. While the commission was in

England and France, the Navy Department was represented by Capt. L. B. McBride. On May 10, 1920, Commander Joseph S. Evans was appointed by the Secretary of the Navy to succeed Commander N. H. Wright. On December 15, 1920, Mr. Ralph E. Flanders was appointed by the Secretary of Commerce, to succeed Mr. James Hartness.

APPENDIX 3. PROCEDURE OF COMMISSION

(*a*) General Procedure.—In its work of establishing standards for screw threads the commission has made particular effort to secure the actual facts concerning the need of standardization and the economic conditions to be provided for in the production and use of screw threads.

The commission has had the advantage of being able to proceed rapidly inasmuch as in recent years the accomplishments of the American Society of Mechanical Engineers and the Society of Automotive Engineers have paved the way toward the adoption of necessary screw-thread standards. Without this preliminary work it would have been considered impracticable and unnecessary. In addition the results accomplished by the British Engineering Standards Committee in their standardization work have been available to the commission and advantage has been taken of the accomplishments realized by this organization. Furthermore the commission has availed itself of the opportunity to secure from such organizations as the Tap Makers Association and representatives of prominent manufacturing concerns valuable information and data regarding the production of tools and appliances for making threaded products, as well as information and data regarding the application and use of screw-thread products.

(*b*) Public Hearings.—After the preliminary organization of the commission immediate steps were taken to secure from various screw-thread authorities and representative manufacturers and users testimony as to the nature of the National standards to be adopted for the use of the Government and for American manufacturers. To secure this information several public hearings were conducted in various industrial centers throughout the country.

Government officials, authorities on screw threads, manufacturers and users of screw-thread products, as well as manufacturers of taps, dies, gages, and other tools required for producing screw-thread products, were invited to attend these hearings and present their views on various phases of the subject. Every effort was made to have in attendance at these hearings representatives of prominent manufacturers and organizations interested in standardization work. To this end invitations were sent to a large mailing list and in addition announcement of the meetings, extending invitations to be present, were published in the technical magazines. Topic sheets were distributed in advance of the hearings in order that witnesses could prepare their views on the subjects of the meeting in a definite, concise, and authentic form.

A large amount of evidence was collected in this way and the opportunity was available for the various members of the commission to bring out by cross-examination information which could have been secured in no other way. This evidence was tabulated for the consideration of the commission in formulating its report.

The following schedule lists the dates of the various hearings:

October 7, 1918

Hearing held in Engineering Societies Building, 29 West Thirty-ninth Street, New York City. Topic—Fastening Screws, questions 1 to 5.

October 21

Hearing held in Engineering Societies Building, 29 West Thirty-ninth Street, New York City. Topic—Pipe Threads, Brass Tubing, Hose Couplings, Special Threads and Instrument Threads as outlined in Topic Sheet.

November 8

Hearing held at Bureau of Standards, Washington, D. C. All topics, as outlined in Topic Sheet.

November 11 and 12

Hearing held at Hotel Statler, Detroit, Mich. All topics, as outlined in Topic Sheet.

November 13

Hearing held at Hotel Miami, Dayton, Ohio. All topics, as outlined in Topic Sheet.

(*c*) Topic Sheet.—The following topics are those which were discussed at the various hearings:

TOPICS FOR DISCUSSION AT HEARINGS OF NATIONAL SCREW THREAD COMMISSION

[N. S. T. C. No. 7. National Screw Thread Commission, October 25, 1918]

(*1*) *Fastening Screws.*—1. As a national standard, is there any objection to the continuation of the U. S. Standard System of thread diameters and pitches for general use in practically its present shape?

2. As a national standard, is there any objection to the adoption of the S. A. E. System of diameters and pitches of fine threads?

3. As a national standard, to what extent could the A. S. M. E. System of standard machine screws be adopted?

4. There seems to be a general feeling that in the standardization of fastening screws tolerances and clearances should be provided to cover several grades of work and to allow for several classes of fit ranging from a stud fit to a very loose fit. Would provision for four classes of fit including the stud fit be sufficient for all grades of work encountered in screws made to the various systems previously mentioned or should such a classification include more than four classes?

5. Is there any objection to adopting the "standard hole" practice for screw threads; that is, the practice of making all the taps for any particular thread of one basic size and securing the required fit by changing the diameter of the screw or male threaded work which is to assemble with the nut cut by the basic tap?

(*2*) *Pipe Threads.*—1. As a national standard, is there any objection to the adoption of the American Briggs pipe-thread sizes for both taper and straight pipe threads as accepted by the American Society of Mechanical Engineers?

2. In view of the experiments on the form of pipe threads conducted by the Pennsylvania Railroad in connection with the American Society of Testing Materials which tend to show the desirability of the U. S. Standard form with flat top and bottom one-eighth of the pitch, do you consider it advisable to adopt the U. S. Standard form instead of the present form which specifies a thread depth of 0.8 of the pitch with a resulting flat at the top and bottom of the thread which is quite small?

3. In your shop practice, to what extent do you employ gages for checking pipe threads and what do you consider a satisfactory tolerance for ordinary commercial work stated in turns either way from the gaging notch?

(*3*) *Brass Tubing.*—1. What is your shop practice in connection with threads cut on various forms of brass tubing?

2. To what extent do you consider it possible to standardize the general practice on the threads used on brass tubing?

(*4*) *Hose Couplings.*—1. As a national standard, is there any objection to the adoption of the hose coupling sizes now known as the National Standard hose couplings in the sizes from 2½ inches to 4½ inches as recommended by the National Fire Protection Association, Bureau of Standards, American Society of Mechanical Engineers, and other organizations?

2. What is your shop practice in the manufacture of hose coupling threads on sizes below 2½ inch?

3. To what extent do you consider it possible to standardize commercial practice in the manufacture of hose-coupling threads on the sizes below 2½ inch?

(*5*) *Acme and Other Special Threads.*—1. What is your shop practice in the manufacture of Acme threads and other special threads used in machine construction?

2. To what extent do you consider it possible to standardize the form of thread and pitches used in the manufacture of Acme threads and to standardize other special threads used in machine construction?

3. To what extent do you consider it possible to standardize the general practice with reference to the diameters used for Acme thread pitches?

(*6*) *Instrument Threads.*—1. In your shop practice in the manufacture of instruments, to what extent do you use the A. S. M. E. threads; the British Association threads; metric threads; or your own special threads, and to what extent do you consider it possible to standardize commercial practice for this class of work?

(*d*) Attendance at Hearings.—The hearings of the commission were well attended by representatives of prominent manufacturers and by authorities on screw-thread subjects as is indicated in the following list of persons attending the various hearings. This attendance was secured in spite of the fact that manufacturers were extremely busy in connection with military preparations.

HEARING AT NEW YORK CITY OCTOBER 7, 1918

Members and Officers of Commission Present—
Dr. S. W. Stratton, chairman.
James Hartness.
F. O. Wells.
E. H. Ehrman.
Major O. B. Zimmerman.
H. L. Van Keuren, executive secretary.
H. W. Bearce, general secretary.

Men Representing Manufacturing Concerns Present—
C. D. Terry, National Tube Co.
George W. Thurston, American Screw Co.
F. O. Lincoln, S. J. Besse, Morse Twist Drill & Mach. Co.
William H. Ure, Eastman Kodak Co., Camera Works.
John C. Dense, Willys-Morrow Co.
J. E. Myers, P. R. R. Test Dept.
Arthur A. Fuller, Watervliet Arsenal.
Wilber C. Searle, Worcester Machine Screw Co.
Charles C. Persiani, Clark Bros. Bolt Co.
E. S. Sanderson, G. H. Wayne, Scovill Manufacturing Co.
Isaac F. Baker, General Electric Co.
Luther D. Burlingame, Brown & Sharpe Manufacturing Co.
A. H. Emery, Glenbrook, Conn.
William B. McIntosh, Coates Machine Tool Co.
E. Burdsall, Russell, Burdsall & Ward Bolt & Nut Co.
Ralph E. Flanders, manager, Jones & Lamson Machine Co.
Erik Oberg, editor, "Machinery."
Charles Glover, H. H. Jones, The Corbin Screw Corp.
Ethan Viall, "American Machinist."
C. B. Buxton, American Locomotive Co.
F. R. Stevens, American Locomotive Co.
J. L. Fitts, Warren Webster Co.
S. F. Newman, Landis Machine Co.
J. J. McBride, American Car & Foundry Co.
W. J. Parsons, Millers Falls Co.
W. Henry Martin, Arthur Knapp Engineering Corp.
Charles H. Jackmus, Ansonia Manufacturing Co.
H. J. Bingham Powell, R. W. Sutherland, British War Mission.
Frederick S. Thompson, Hartford Machine Screw Co.
F. J. Echols, Pratt & Whitney Co.
Frank A. Turner, Becker Milling Machine Co.
Will R. Porter, S. S. White Dental Manufacturing Co.
Werner O. Olson, Edison Phonograph Works.
A. H. Moore, General Electric Co.
F. J. Cole, American Locomotive Works.

HEARING AT NEW YORK CITY OCTOBER 21, 1918.

Members and Officers of Commission Present—
Dr. S. W. Stratton, chairman.
James Hartness.
F. O. Wells.
E. H. Ehrman.
Lieut. Col. E. C. Peck.
Maj. O. B. Zimmerman.
H. L. Van Keuren, executive secretary.
H. W. Bearce, general secretary.

Men Representing Manufacturing Concerns Present—
J. E. Myers, P. R. R. Test Dept.
C. M. Pond, Pratt & Whitney Co.
D. W. Roberts, American Brass & Copper Co.
J. C. Meloon, General Fire Extinguisher Co.
C. D. Terry, National Tube Co.
C. E. Skinner, Westinghouse Electric & Manufacturing Co.
Thomas K. Bigg, Bridgeport Brass Co.
F. M. Griswold, General Inspector, National Board Fire Underwriters.
J. Q. Salisbury, National Cash Register Co.
William H. Ure, Eastman Kodak Co.
I. F. Baker, General Electric Co.
G. H. Woodroffe, Parkesburg Iron Co.
George M. Bond, Hartford, Conn.
F. J. Cole, American Locomotive Works.
Frank A. Turner, Becker Milling Machine Co.
Richard L. Wilcox, Waterbury Foundry & Machine Co.
William Prellwitz, Ingersoll-Rand Co., A. S. Cameron Steam Pump Co.
Frederick R. Banks, McNab & Harlin Manufacturing Co.
William H. Burt, Waterbury Manufacturing Co.
N. R. Butler, Worthington Pump & Mach. Corp.
Edwin L. White, president J. H. White Manufacturing Co.
G. B. Peckop, Malleable Iron Fitting Co.
C. W. Stephen, Pratt & Cady Co. Incorporated.
B. H. Blood, Pratt & Whitney Co.
Ethan Viall, managing editor "American Machinist."
William J. Baldwin, consulting engineer, World Building, New York City.
H. Koester, The Bristol Co.
George R. Bott, The Norma Co. of America.
S. F. Newman, Landis Machine Co.
H. J. Bingham Powell, British War Mission.
A. M. Hauser, Crane Co.
A. Bousfield, The Fairbanks Co.
T. H. Blackmore, J. L. Mott Iron Works.
Joseph E. Stutz, Thomas Devlin Manufacturing Co.
William Ferber, Keuffel & Esser Co.

HEARING AT WASHINGTON, D. C., NOVEMBER 8, 1918.*

Members and Officers of Commission Present.—
Dr. S. W. Stratton, chairman.
James Hartness.
F. O. Wells.
E. H. Ehrman.
Lieut. Col. E. C. Peck.
Maj. O. B. Zimmerman.
Commander S. M. Robinson.
Commander E. J. Marquart.
H. L. Van Keuren, executive secretary.
H. W. Bearce, general secretary.
Lieut. Robert Lacy, assistant secretary.

Men Representing Government Departments Present.—
E. C. Gillette, Bureau of Lighthouses.
R. H. Shappell, Bureau of Engraving and Printing.
Horace K. West, Walworth Manufacturing Co.
H. W. Groff, Frankford Arsenal.
Lieut. A. N. Van Nostrand, Signal Corps, Elec. Eng. Section.
H. H. Farr, Machinery and Small Arms Section.
Capt. F. R. Mead, Gage Section, Insp. Division.
Capt. Bordinat, Trench Warfare Section.
F. H. Walsh, Bureau of Construction and Repair.

*Mr. J. B. Thomas, designated by Mr. H. T. Herr as his representative, attended this and subsequent sessions of the Commission.

K. D. Williams, Bureau of Steam Engineering.
Maj. H. B. Pratt, U. S. Marine Corps.
W. E. Krotee, Inst. Section, Ordnance Office.
J. S. Wiley, Ord. Eng. Equipment Section.
F. A. Hunnewell, constructor, U. S. Coast Guard.
Ensign A. J. Mummert, U. S. N. R. F., Bureau of Steam Engineering.
Commander S. M. Henry, Bureau of Construction and Repair.
E. G. Fischer, U. S. Coast and Geodetic Survey.
Archibald Black, Spec. Section, Aircraft Division.
Ensign D. W. Kent, U. S. N. R. F., Bureau of Steam Engineering.
Lucian C. Jackson, Engine Production Section.
Admiral George A. Burd, care of Commandant, Navy Yard, New York City.
D. A. Gurney, Mobile Gun Carriage Section.
Lieut. Cause, Gage Section, Army Ordnance Dept.
Capt. Q. B. Newman, U. S. Coast Guard.
J. B. Thomas, Westinghouse Elec. & Mfg. Co.

HEARING AT DETROIT, MICH., NOVEMBER 11, 1918

Members and Officers of Commission Present.—
Dr. S. W. Stratton, chairman.
James Hartness.
F. O. Wells.
E. H. Ehrman.
Lieut. Col. E. C. Peck.
Maj. O. B. Zimmerman.
H. L. Van Keuren, executive secretary.
H. W. Bearce, general secretary.
Lieut. Robert Lacy, assistant secretary.

Men Representing Manufacturing Concerns Present.—
W. J. Pasinski, Burroughs Adding Machine Co.
W. H. Urquhart, Curtis F. Smith, Michigan Bolt and Nut Works.
C. C. Bartlett, Crane Co.
R. W. Davis, Mitchell Motors Co.
Robert P. Smith, Packard Motor Car Co.
Paul H. McCain, Pheoll Manufacturing Co.
D. A. Wallace, Western Electric Co.
F. A. Whitten, General Motors Truck Co.
Charles Olsen, Continental Motor Manufacturing Co.
Mr. Cedarstrom, Morgan & Wright.
B. N. Ackles, T. R. Rayl Co.
J. B. Thomas, Westinghouse Elec. & Mfg. Co.
George E. Goddard, Dodge Bros.
C. A. Knill, C. H. Besly & Co.
W. C. Yeatman, Chicago Nut Co.
C. C. Rhode, Champion Spark Plug Co.
H. I. Woolsen, mechanical engineer, The Studebaker Corp.
E. Mauren, Solvay Process Co.
Ernest T. Bysshe, Bureau of Aircraft Production.
A. E. Buelow, Lamson & Sessions Co.
T. McLaughlin, Roe Stephens Manufacturing Co.
H. S. Huncke, Detroit manager, Greenfield Tap & Die Corp.

HEARING AT DAYTON, OHIO, NOVEMBER 13, 1918.

Members and Officers of Commission Present—
James Hartness, vice chairman.
F. O. Wells.
E. H. Ehrman.
Lieut. Col. E. C. Peck.
Major O. B. Zimmerman.
Commander E. J. Marquart.
H. L. Van Keuren, executive secretary.
H. W. Bearce, general secretary.
Lieut. Robert Lacy, assistant secretary.

Men Representing Manufacturing Concerns Present—
A. S. Hendricks, W. H. McCarthy, Computing Scale Co.
George A. Decker, S. Lawson, Warner & Swasey Co.
H. Ritter, Lukenheimer Manufacturing Co.
R. V. Hutchinson, Dayton-Wright Aeroplane Co.
L. C. Jackson, Engine Production Section.
William F. Hoffman, superintendent, Robbins & Myers Co.
Frank L. Walker, Z. C. Bradford, Dayton Engineering Laboratory.
A. I. Fischer, National Association of Brass Manufacturers.
M. T. Byrne, Davis Sewing Machine Co.
J. F. Harrison, Atlas Bolt and Screw Co.
C. E. Watterson, Sheffield Machine and Tool Co.
J. B. Johnson, Bureau of Aircraft Production.
Ernest T. Bysshe, Bureau of Aircraft Production, Section of Gages and Standards.
J. B. Thomas, Westinghouse Elec. & Mfg. Co.

(*e*) PERSONS ATTENDING MEETINGS OF THE COMMISSION.—In addition to the evidence secured at the various hearings, there were several instances where special representatives or authorities on screw-thread subjects were called for conference with the commission during its meeting at Washington. In this connection, the following persons were in attendance at one of the meetings of the commission·

Herbert Chase, representing the Society of Automotive Engineers.
H. J. Bingham Powell, representing the British Ministry of Munitions.
C. A. Powell, representing the British Ministry of Munitions.
Representative J. Q. Tilson.
J. E. Ducard, representing the French High Commission.
F. G. Echols, representing the Tap Makers Association.

(*f*) EXPERIMENTS.—A large number of experiments and tests were made by the Bureau of Standards to verify the results obtained by the consideration of the data collected at the various hearings and also in connection with the development of tolerances and other technical subjects considered by the commission. In addition to the experiments conducted by the Bureau of Standards, several of the members of the commission conducted experiments and research work at their own expense.

(*g*) Meetings of the Commission.—Meetings of the commission were called for the purpose of outlining and formulating the procedure and for considering the information collected at the various hearings and for the formulation of the progress report of the commission. The meetings held were as listed in the following schedule:

September 12 and 15, 1918.—preliminary informal meeting for the purpose of considering the organization and outlining of a program.

September 23 and 24, 1918.—Completing program and formulating topics for hearings.

November 21 and 22, 1918.—Meeting of subcommittees and commission for outlining and formulating progress report.

December 20 and 21, 1918.—Meeting of the commission for considering the possibilities of an international standard of screw thread; extension of time of commission; and perfecting the progress report.

December 28, 1918.—Meeting of subcommittee on Terminology.

January 6, 1919.—Meeting of subcommittee on Classification and Tolerance, Hotel Winton, Cleveland, Ohio.

January 7, 1919.—Meeting of subcommittee on Pitches, Thread Systems, and Form of Thread, Hotel Statler, Buffalo, N. Y.

January 20 to 24, 1919.—Meeting of commission for perfecting the progress report.

February 17 to 19, 1919.—Meeting of commission for consideration of tentative report.

March 24 and 25, 1919.—Meeting of commission for further consideration of tentative report.

April 7 to 9, 1919.—Meeting of subcommittee on Classification and Tolerances, Cleveland, Ohio.

April 14 to 16, 1919.—Meeting of subcommittee on Classification and Tolerances, Cleveland, Ohio.

April 28 and 29, 1919.—Meeting of commission for further consideration of tentative report.

May 26 and 27, 1919.—Meeting of commission for further consideration of tentative report.

July 28 to 30, and August 8, 1919.—Meetings with British Engineering Standards Association, London, England.

August 11 and 14, 1919.—Meetings with Société d'Encouragement pour l'Industrie Nationale, Paris, France.

September 15, 1919.—Meeting of commission to hear report of European conferences.

October 6, 1919.—Meeting of commission in New York City to consider report of manufacturers and users of screw-thread products with reference to tentative report.

November 24 and 25, 1919.—Meeting of commission in Cleveland, Ohio, to consider final form of tentative report.

APPENDIX 4. HISTORICAL

(*a*) General.—The initial accomplishments in the standardization of screw threads in the United States was the report under date of December 15, 1864, of the special committee appointed by the Franklin Institute on April 21, 1861, for the investigation of a proper system of screw threads, bolt heads and nuts, to be recommended by the Institute for adoption and general use by American engineers.

In its report this committee recommended a thread system designed by William Sellers. This thread system specified a single series of pitches for certain diameters from ¼ in. to 6 ins., inclusive. The threads had an included angle of 60° and a flat surface at the crest and root equal to one-eighth of the pitch. This system is known and used at the present time as the Franklin Institute Thread, the Sellers Thread, and commonly as the United States Thread.

The accomplishments realized in the adoption of the Franklin Institute or United States Standard Thread in 1864 were brought about largely by the great need of standard threads by American railroads for the development of their lines and equipment.

While the United States Standard Thread System fulfilled a great need in the development of our great railway systems, it did not fully meet the requirements of the automobile, machine-tool, instrument, and light-machinery industries. The requirements of these industries made apparent the need of additional standard threads and to fulfill these needs a thread system having finer pitches than the United States Standard System was recommended by the Society of Automotive Engineers; and a machine-screw thread series which provided smaller size screws than the United States Standard Threads was recommended by the American Society of Mechanical Engineers. The progress of machine design and manufacture has established an extensive use of these fine thread series.

Previous to the war, America led in many lines of quantity production. The war has brought about a great extension in quantity production in other countries. One of the prerequisites of quantity production is standardization of form and dimensions of parts, in order that interchangeability may be established. This is especially important in the matter of screw-thread parts since there are two mating parts that must fit and these parts in many cases are made in different places. Standardization is important to both the manufacturer and the user of a machine, as the user should be able to buy locally a screw or nut for replacement in case of breakage or wear.

(*b*) Bibliography.—A very complete bibliography of screw-thread literature has been prepared by Henry E. Haferkorn, librarian Engineer School Library, Washington Barracks, D. C., and published as Supplement 2, Professional Memoirs, November–December, 1918, Volume X, No. 54.

APPENDIX 5. TECHNICAL

(*a*) Screw-Thread Fits.—With reference to the classification of screw-thread fits, attention is called to the fact that the minimum threaded hole or nut corresponds to the basic size; that is, the pitch diameter of the minimum nut is basic for all classes of fit. This condition permits the use of taps which when new are oversize and which are discarded when the hole cut is at the basic size.

In order to secure the desired fit the screw size is varied; the maximum screw corresponds to the basic size for the Medium-Fit Class, is slightly above basic size for Close-Fit Class, considerably above the basic size in the Wrench-Fit Class, and below the basic size for the Loose-Fit Class.

(*b*) Application of Tolerances on Screw Thread Product.—The tolerances specified in Column 7 of Tables 5, 10, 13, and 16, Section V, are the net tolerances which are in no way reduced by permissible manufacturing tolerances provided for master gages. These master-gage tolerances are provided for by being added to the net tolerances. Thus the extreme or drawing tolerances are the net working tolerances increased by the master-gage increment or equivalent diametrical space required to provide for the master-gage tolerances. The limits established for the extreme tolerances should in no case be exceeded. The application of gage tolerances in relation to tolerances allowed on the work can be best understood by considering that the extreme tolerances represent the absolute limits over which variations of the work must not pass. The manufacturing tolerances required for limit master gages are then deducted from the extreme tolerances producing the figures specified as net tolerances. Further reduction of the extreme tolerances is caused by the manufacturing tolerances required for the inspection gages and working gages.

It is essential that the proportion of the tolerance used by the workmen producing the work at the machine be well within the net tolerance limits. The net tolerance limits as established by the master gages may be considered as the largest circle of the target, the space occupied by the master-gage tolerances representing the width of the line establishing the largest circle. The marksman always aims to hit the bull's-eye. Any mark inside of the largest circle or cutting the circle scores. Any mark outside of the largest circle does not score. The same is true in producing work: The careful manufacturer will aim to produce work which is in the center of tolerance limits. The bull's-eye in this case, which is the working tolerance used

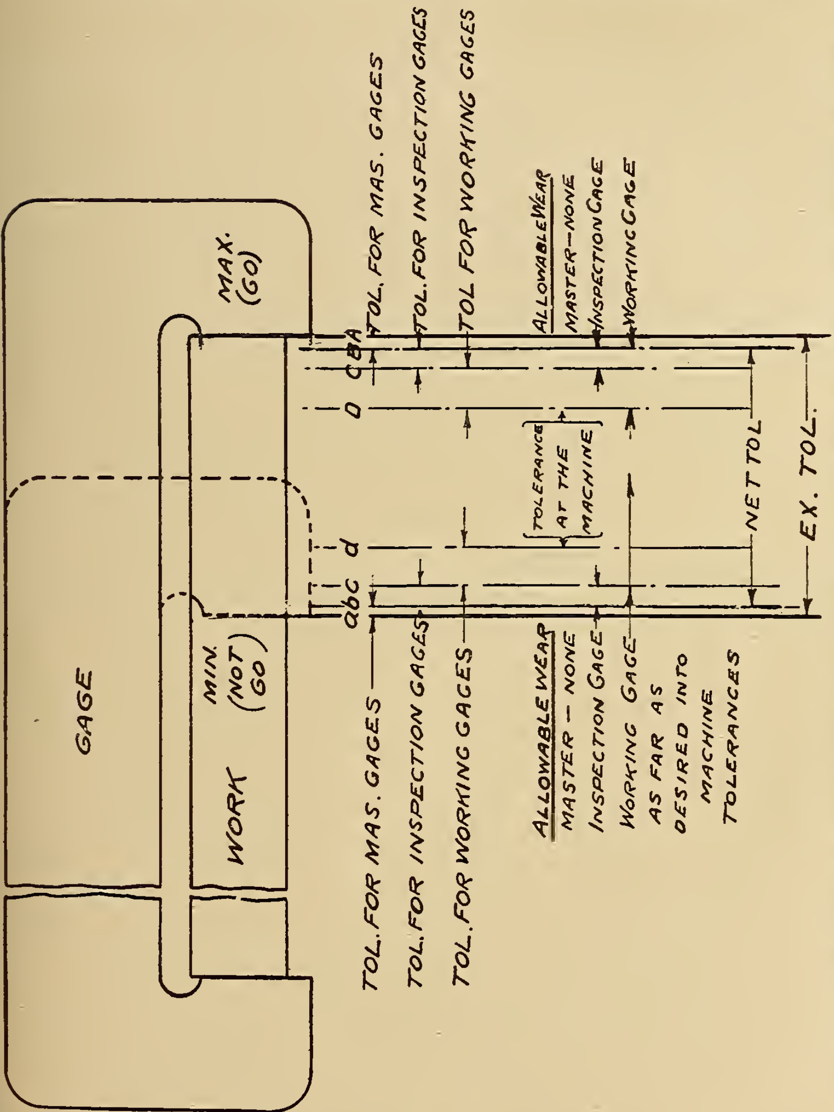


FIG. 41.—*Illustration of relation between gage sizes, tolerances, and wear limits, and dimensions of gaged internal part*

For gaging an external part, tolerances and wear are provided for in a similar manner

at the machine, will be considerably less than the net tolerance and the result will be that a very large percentage of the work will be accepted, and spoiled or rejected work will be reduced to practically nothing. If the net tolerance limits are used as working limits at the machine, there will be a larger percentage of rejections due to differences in gages and wear of both tools and gages. The application of this principle is illustrated in Fig. 41.

(*c*) Disposition of Gage Tolerances.—Fig. 41 is a diagram which shows the relative position of master-gage, inspection-gage, and working-gage tolerances with reference to the net tolerance allowed on the work.

(*1*) *Extreme Working Limits.*—The extreme limits as shown by the lines *A* and *a* in Fig. 41 represent the absolute limits within which all variations of the work must be kept, including permissible variations provided for manufacturing tolerances on master gages. The manufacturer of the product should not be concerned with the extreme tolerances, but should work within the net tolerance limits. The extreme tolerance limits are included for the manufacturer or inspector of master gages, and, in no case, should master gages be approved which are outside of the dimensions established by these extreme limits.

(*2*) *Net Working Tolerance Limits.*—The lines at *b* and *B* represent the net working tolerance limits within which all manufactured product must come.

(*3*) *Master-Gage Tolerances.*—The regions *A B* and*ab* represent the space required to provide for the "Go" and "Not Go" master-gage tolerances, respectively.

(*4*) *Master Gages Represent Net Tolerance Limits.*—Master gages provide physical standards representing the limits placed on the work. The master-gage tolerances are placed within the extreme tolerance limits. However, the manufacturer receives the full benefit of the specified net tolerance. So far as the manufacturer is concerned, he should, in no case, permit variations in the work produced to extend beyond the limits established by his master gages.

(*5*) *Inspection Gage Tolerances.*—The regions *BC* and *bc* represent the space required to provide for the "Go" and "Not Go" inspection-gage tolerances, respectively. The inspection-gage tolerances are placed inside the net tolerance limits.

(*6*) *Working-Gage Tolerances.*—The regions *DC* and *dc* represent the space required to provide for the "Go" and "Not Go" working-gage tolerances, respectively. These working-gage tolerances are placed within the net tolerance limits. This insures that any work accepted by the working gage will be accepted by the inspection gage, and that work accepted by both working gage and inspection gage will be within the net tolerance limits.

(*d*) Wear on "Go" Gages.—The "Go" master gage is not to be used on the product. It serves as a standard for comparative measurements or as a check for verifying the inspection or working gage. It also serves as a standard representing the wear limit for the inspection or working gage. The "Go" master gage is, therefore, not subject to wear.

The "Go" inspection gage may wear until it reaches the size represented by the master gage. As shown in Fig. 41 the wear provided for the inspection gage is that which takes place within its own tolerance region. However, a definite allowance for wear may be provided for the "Go" inspection gage in addition to its tolerance region if desired.

The "Go" working gage wears within its own tolerance limits and through the inspection-gage tolerance region and continues to properly accept work until worn to the dimension established by the "Go" master gage. It is good practice to transfer the "Go" working gage to use as an inspection gage when it is worn so that its dimension corresponds to that of the inspection gage.

(*e*) Wear on "Not Go" Gages.—The "Not Go" master gage is not to be used on the product. It serves as a standard for comparative measurements or as a check to verify the inspection or working gage. It is therefore not subject to wear.

The "Not Go" inspection gage wears within its own tolerance region and into the tolerance region established for the "Not Go" working gage. It is good practice to transfer the "Not Go" inspection gage to use as a working gage when it is worn so that its dimension corresponds to that of the "Not Go" working gage.

The "Not Go" working gage wears within its own tolerance region into the working tolerance. It is purely an economic question as to when the "Not Go" working gage should be discarded due to wear, inasmuch as continued use reduces the working tolerance, the result of which must be balanced against the cost of a new gage.

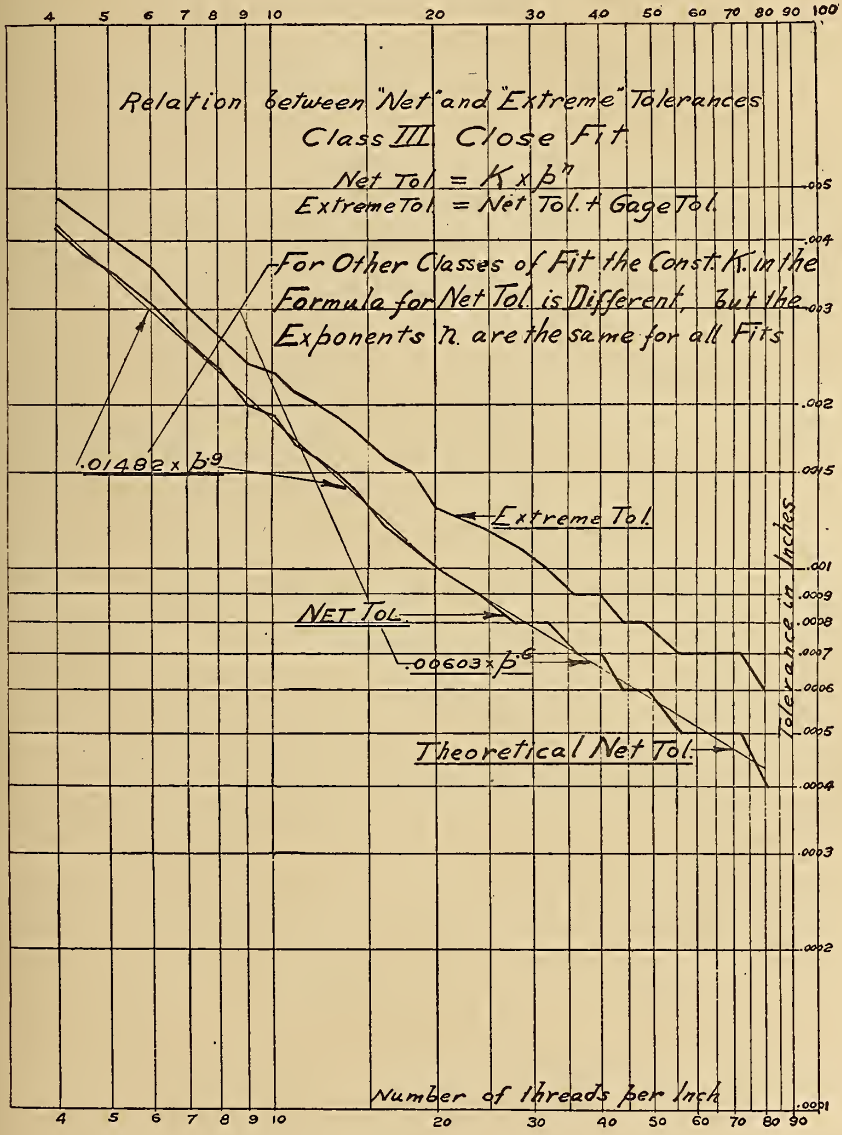


FIG. 42.—*Illustration of relation between extreme tolerance and net tolerance*

(*f*) RELATION BETWEEN EXTREME TOLERANCE AND NET TOLERANCE SHOWN GRAPHICALLY.—The relation between the extreme tolerance and the net tolerance for Class III, Close Fit, is shown graphically in Fig. 42.

The tolerances and allowances for Classes I, II-A, II-B, and III are shown in Tables 5, 10, 13, and 16, Section V.

APPENDIX 6. GAGES AND METHODS OF TEST

The general subject of gaging screws is too extensive to be fully covered in this report. Reference is made, however, to bulletins published by the Bureau of Standards covering various inspection methods, including the standard ring and plug gages, and the optical projection method of gage inspection; also, to an article in the Journal of American Society of Mechanical Engineers of February, 1919, with reference to the use of the projection lantern for gaging work.

Inasmuch as the threaded-plug and ring limit gages are the most universally used scheme of gaging, and one that has been brought to the highest state of refinement, there is set forth herein what is considered the best practice used in the production and use of such gages. It is understood, however, that it is not the intention of this commission to confine manufacturers to any particulary method of gaging, as that would tend to hinder progress.

It has been the practice of many manufacturers including Government shops, to work with "Go" gages only and to depend upon the judgment of good workmen to keep within proper limits by the amount of "shake" or difference between the work and the gage. With a highly skilled and trained force working on but one kind of work and also referring the working gage to but one master gage, a fair degree of interchangeability can be maintained under these conditions.

In the recent military preparations, the Government required munitions in such vast quantities and in such a short period of time that this method of insuring interchangeability failed, and a method of gaging had to be established which did not rely entirely upon the skill and judgment of the workmen or inspectors. One reason for the necessity of a complete gaging system was that it was not possible to obtain a sufficient number of skilled workmen or inspectors. Furthermore, one master gage could not be used all over the country and consequently discrepancies in measurement between different shops had to be guarded against by the use of properly tested standards and by approved methods of measuring.

It is believed that the experience gained by manufacturers producing war material will result in a much more extensive use of gages than was ever thought practicable during prewar times The gage specifications which are given herein cover the manufacture, use, and application of a system of gaging which has been thoroughly demonstrated in the execution of war contracts as being adequate for the production in large quantities of strictly interchangeable screw-thread product. It is not the intention of this report to limit manufacturers to any particular methods of test in checking either the manufactured product or in measuring gages, for the reason that any specification which would tend to limit the development of new and improved methods of measuring would be very undesirable. However, when the ordinary forms of thread gages are used, the specifications given herein will apply.

(*a*) FUNDAMENTALS.—The specifications for gages given herein are built upon the following fundamental assumptions:

(1) Approved limit master gages do not reduce the net working tolerance.

(2) Permissible errors in *angle of thread* specified for "Go" gages tend to reduce the net working tolerance, while similar permissible errors on the "Not Go" gage tend to increase the net working tolerance. These two factors, therefore, balance each other.

(3) Permissible *lead errors* specified for the "Go" gage reduce the net working tolerance, while permissable lead errors on the "Not Go" gage tend to increase the net working tolerance.

(4) In order to realize the full net working tolerance, the permissible diametrical variation specified for both "Go" and "Not Go" gages (gage increment) is placed outside of the net tolerance limits. The extreme tolerance equals the net tolerance plus gage increment.

(5) The "Go" gage should check simultaneously all elements of the thread (all diameters, lead, angle, etc.).

(6) The "Not Go" gage should check separately the elements of the thread.

(*b*) GENERAL SPECIFICATIONS.—The following general specifications refer in particular to gaging systems which have been found satisfactory by the Army and Navy for the production of interchangeable parts as specified under the subject of "Classification and Tolerances." These specifications are included for the use of manufacturers where definite information is lacking. They are not to be considered mandatory

(*1*) *Gage Classification.*—Thread gages may be included in one of four classes, namely, Standard Master Gages, Limit Master Gages, Inspection Gages, and Working Gages.

(*2*) *Standard Master Gage.*—The Standard Master Gage is a threaded plug representing as exactly as possible all physical dimensions of the nominal or basic size of the threaded component. In order that the Standard Master Gage be authentic, the deviations of this gage from the exact standard should be ascertained by the National Bureau of Standards and the gage should be used with knowledge of these deviations or corrections.

(*3*) *Limit Master Gages.*—Limit Master Gages are for reference only. They represent the extreme upper and lower tolerance limits allowed on the dimensions of the part being produced. They are often of the same design as inspection gages. In many cases, however, the design of the master gage is that of a check which can be used to verify the inspection or working gage.

(*4*) *Inspection Gages.*—Inspection Gages are for the use of the purchaser in accepting the product. They are generally of the same design as the working gages and the dimensions are such that they represent nearly the net tolerance limits on the parts being produced. Inasmuch as a certain amount of wear must be provided on an inspection gage, it can not represent the net tolerance limit until it is worn to master-gage size.

(*5*) *Working Gages.*—Working Gages are those used by the manufacturer to check the parts produced as they are machined. It is recommended that the working gages be made to represent limits considerably inside of the net limits in order that sufficient wear will be provided for the working gages, and in order that the product accepted by the working gages will be accepted by the inspection gages.

(*6*) *Inspection and Working-Gage Sets for Screws.*—The following list enumerates the inspection and working gages required for producing strictly interchangeable screws as specified for National Coarse Threads, National Fine Threads, or other straight threads.

(*i*) A maximum or "Go" ring thread gage, preferably adjustable, having the required pitch diameter and minor diameter. The major diameter may be cleared to facilitate grinding and lapping.

(*ii*) A minimum or "Not Go" ring thread gage, preferably adjustable, to check only the pitch diameter of the threaded work.

(*iii*) A maximum or "Go" plain ring gage to check the major diameter of the threaded work.

(*iv*) A minimum or "Not Go" snap gage to check the major diameter of the threaded work.

(*7*) *Inspection and Working-Gage Sets for Nuts.*—The following list enumerates the inspection and working gages required for producing strictly interchangeable nuts, as specified for National Coarse Threads, National Fine Threads, or other straight threads.

(*i*) A minimum or "Go" thread plug gage of the required pitch diameter and major diameter. The minor diameter of the thread plug gage may be cleared to facilitate grinding and lapping.

(*ii*) A maximum or "Not Go" thread plug gage to check only the pitch diameter of the threaded work.

(*iii*) A "Go" plain plug gage to check the minor diameter of the threaded work.

(*iv*) A "Not Go" plain plug gage to check the minor diameter of the threaded work.

(*8*) *Limit Master Gages Required for Checking Working or Inspection Gages Used on Screw.*—The following list enumerates the limit master gages required for the verification of the working or inspection gages as previously listed for verifying the screw.

(*i*) A set plug or-check for the maximum "Go" thread ring gage, having the same dimensions as the largest permissible screw.

(*ii*) A set plug or check for the minimum or "Not Go" thread ring gage having the same dimensions as the smallest permissible screw.

(*iii*) A maximum plain plug for checking the minor diameter of both the "Go" and "Not Go" inspection thread ring gage.

(9) *Limit Master Gages Required for Checking Working or Inspection Gages Used on Nut.*—The following list enumerates the limit master gages required for the verification of the working or inspection gages as previously listed for verifying the nut.

(*i*) A minimum or "Go" threaded plug to be used as a reference for comparative measurements and corresponds to the basic dimension, or standard master gage.

(*ii*) A maximum or "Not Go" threaded plug to be used as a reference for comparative measurements and corresponds to the largest permissible threaded hole.

(*iii*) A minimum plain ring gage to check the major diameter of the "Go" and "Not Go" master threaded plug unless suitable measuring facilities are available for this purpose.

(*10*) *Material.*—Gages may be made of a good grade of machinery steel pack-hardened, or of straight carbon steel of not less than 1 per cent carbon; or preferably of an oil-hardening steel of approximately 1.10 per cent carbon and 1.40 per cent chromium.

(*11*) *Handles and Marking.*—Handles should be made of a good grade of machinery steel plainly marked to identify the gage.

(*c*) *Design and Construction.*—The following specifications will be helpful in the design and construction of gages used for producing threaded work.

(*1*) *Plain Plug Gages.*—(*i*) *Type.*—All plain plug gages should be single-ended. Plain plug gages of 2 inches and less in diameter should be made with a plug inserted in the handle and fastened thereto by means of a pin. Plain plug gages of more than 2 inches in diameter should have the gaging blank so made as to be reversible. This can be accomplished by having a finished hole in the gage blank fitting a shouldered projection on the end of the handle, the gage blank being held on with a nut.

The "Go" plain plug gage should be noticeably longer than the "Not Go" plain plug gage, or some distinguishing feature in the design of the handle should be used to serve as a ready means of identification, such as a chamfer on the handle of the "Go" gage.

(*2*) *Plain Ring Gages.*—(*i*) *Type.*—Both the "Go" and "Not Go" gages should have their outside diameters knurled if made circular.

The "Go" gage should have a decided chamfer in order to provide a ready means of identification for distinguishing the "Go" from the "Not Go" gage.

(*3*) *Snap Gages.*—(*i*) *Type.*—Snap gages may be either adjustable or nonadjustable. It is recommended that all snap gages up to and including one-eighth inch be of the built-up type. For larger snap gages, forge blanks, flat plate stock or other suitable construction may be used.

Sufficient clearance beyond the mouth of the gage should be provided to permit the gaging of cylindrical work.

Snap gages for measuring lengths and diameters may have one gaging dimension only, or may have a maximum and minimum gaging dimension, both on one end, or maximum and minimum gaging dimension on opposite ends of the gage. When the maximum and minimum gaging dimensions are placed on opposite ends of the gage, the maximum or "Go" end of the snap gage will be distinguished from the minimum or "Not Go" end by having the corners of the gage on the "Go" end decidedly chamfered.

(4) *Plug Thread Gages*—(*i*) *Type*.—All plug thread gages should be single-ended. Thread plug gages 2 inches and less in diameter should be made with a plug inserted in a handle and fastened thereto by means of a pin.

Plug gages of more than 2 inches in diameter, unless otherwise specified, should have the gaging blank so made as to be reversible. This can be accomplished by having the finished hole in the gage blank fitting a shouldered projection on the end of the handle, the gage blank being keyed on and held with a nut.

"Not Go" thread plug gages should be noticeably shorter than the "Go" thread plug gages, in order to provide a ready means of identification, or the handle of the "Go" gage should be chamfered.

End threads on plug thread gages should not be chamfered, but the first half turn of the end thread should be flattened to avoid a feather edge.

(*ii*) *Dirt Grooves*.—Inspection and working thread plug gages should be provided with dirt grooves which extend into the gage for a depth of from one to four threads.

(*iii*) *Length of Thread*.—The length of thread parallel to the axis of the gage should for all standard "Go" thread plug gages, be at least as much as the quantity expressed in the following formula:

$$L = \ldots5)D$$

Where L=length of thread
D=basic major diameter of thread.

For threaded work of shorter length of engagement than $(1.5)D$, the length of thread on the "Go" gage may be correspondingly shorter.

(5) *"Not Go" Thread Gage for Pitch Diameter Only*.—All "Not Go" thread plug gages should be made to check the pitch diameter only. This necessitates removal of the crest of the thread so that the dimension of the major diameter is never greater than that specified for the "Go" gage, and also removing the portion of the thread at the root of the standard thread form. (See Fig. 43.)

(6) *Ring Thread Gages*—(*i*) *Type*.—All ring thread gages should be made adjustable. The "Go" gage should be distinguished from the "Not Go" gage by having a decided chamfer and both gages are to have their outside diameter knulred if made circular.

The end threads on ring thread gages should not be chamfered but the first half turn of the end thread should be flattened to avoid a feather edge.

(7) *Length of Thread*.—The length of thread parallel to the axis of the gage should, for all standard "Go" ring thread gages, be at least as great as the quantity determined in the following formula:

$$L=(1.5)D$$

Where L=length of thread
D= basic major diameter of thread.

For threaded work of shorter length of engagement than $(1.5)D$, the length of thread on the "Go" gage may be correspondingly shorter.

(8) *"Not Go" Ring Gage for Pitch Diameter Only*.—"Not Go" ring thread gages should be made to check the pitch diameter only. This necessitates removal of the crest of the thread so that the dimension of the minor diameter is never less than that specified for the maximum or "Go" gage and also removing the portion of the thread at the root of the standard form. (See Fig. 43.)

(*iiii*) *Gage Tolerances*.—There are specified herein for use in the production of National Coarse Threads, National Fine Threads, National Hose-Coupling Threads, and for other straight threads, and for National Pipe Threads, several tables of gage manufacturing tolerances.

Table 30 will be found practicable for all plain plug, ring, and snap gages used in connection with a measurement of screw-thread diameters. In addition to the

NOTE.—"Not go" gages check pitch diameter only.

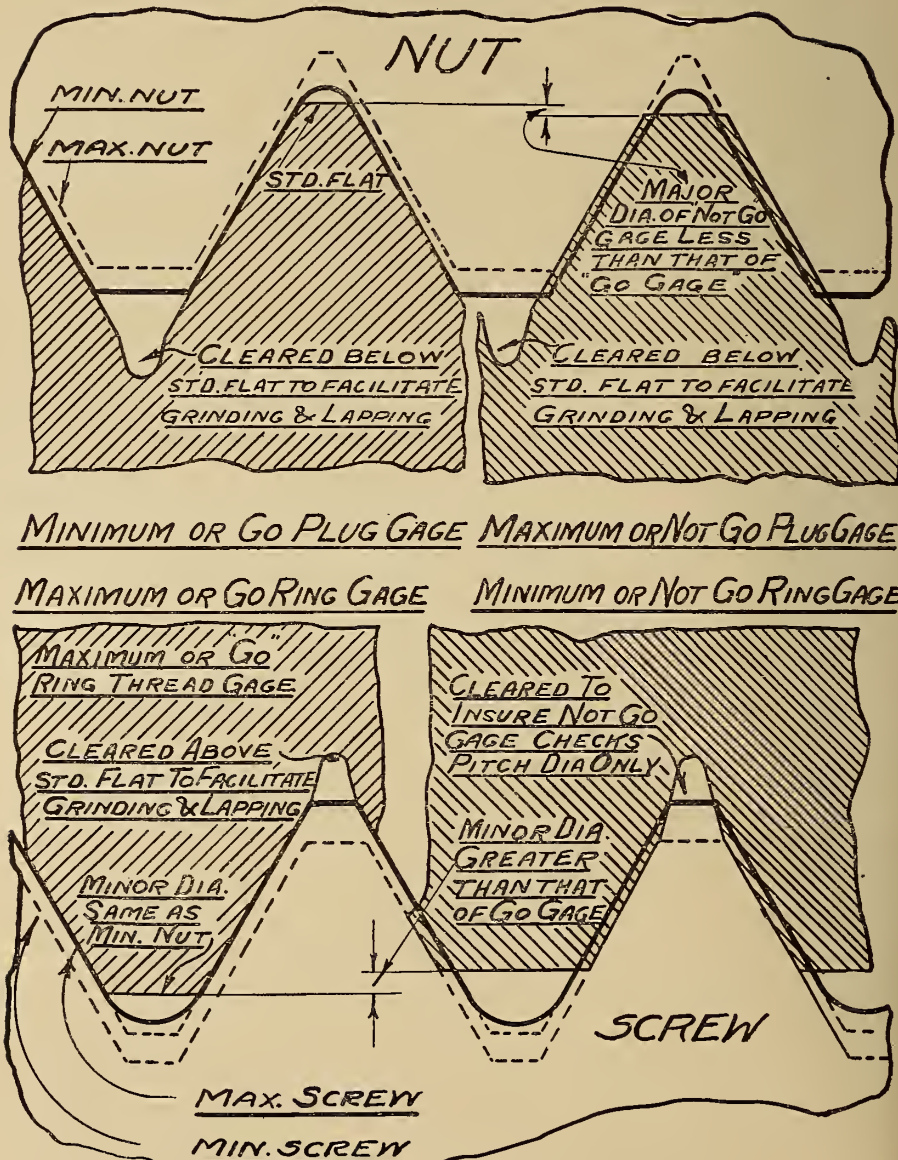


FIG. 43.—*Illustration of "go" and "not go" plug and ring gages*

master-gage tolerances, suggested tolerances for inspection and working gages are also given in Table 30.

Table 31 will be found practicable for both standard and limit master thread gages for thread work designed in accordance with the manufacturing tolerances for Class I, Loose Fit, and Class II, Medium Fit, made to Tables 5, 10, and 13, Section V.

Table 32 contains suggested manufacturing tolerances for inspection thread gages with a small allowance for wear for use in quantity production of Class I, Loose Fit, and Class II, Medium Fit thread work, made to Tables 5, 10, and 13, Section V.

Table 33 contains suggested manufacturing tolerances for working thread gages with a small allowance for wear for use in quantity production of Class I, Loose Fit, and Class II, Medium Fit thread work, made to Tables 5, 10, and 13, Section V.

Table 34 contains the tolerances suggested for both standard and limit master thread gages for work designed in accordance with manufacturing tolerances for Class III, Close Fit thread work, made to Table 16, Section V. As the component tolerances for this class are relatively small, it is believed that the working gages will be required to be held within the gage tolerances shown in Table 34.

(*e*) Application of Gage Tolerances.—(*1*) *Tolerances for Plain Gages.*—For plain plug gages, plain ring gages, and plain snap gages required for measuring diameters of screw-thread work, the gage tolerances specified in Tables 31, 32, 33, and 34 should be used. Attention is called to the fact that the tolerances on thread diameters vary in accordance with the number of threads per inch on the screw or nut being manufactured. In manufacturing a plain plug, ring or snap gage, in the absence of information as to the number of threads per inch of the screw to be made, or for gage dimensions other than thread diameters, the tolerances for plain gages given in Table 30 may be used.

(*2*) *Tolerances on Lead.*—The tolerances on lead are specified as an allowable variation between any two threads not farther apart than the length of thread engagement as determined by the following formula:

$$L=(1.5)\,D$$

where

L=length of thread engagement
D=basic major diameter of thread.

(*3*) *Tolerances on Angle of Thread.*—The tolerances on angle of thread as specified herein for the various pitches are tolerances on one-half of the included angle. This insures that the bisector of the included angle will be perpendicular to the axis of the thread within proper limits. The equivalent deviation from the true thread form caused by such irregularities as convex or concave sides of thread, rounded crests, or slight projections on the thread form, should not exceed the tolerances allowable on angle of thread.

(*4*) *Tolerances on Diameters.*—The tolerances given for thread diameters in Tables 31, 32, 33, and 34 are applied in such a manner that the tolerances permitted on the inspection and working gages occupy part of the extreme tolerance. This insures that all work passed by the gages will be within the tolerance limits specified on the part drawing as represented by the limit master gages. The tolerances given also permit the classification and selection of gages, so that if a gage is not suitable for a master gage it may be classified and used as an inspection or working gage, provided that the errors do not pass outside of the net tolerance limits.

The application of the tolerances on diameters of thread gages is exactly the same as explained herein for plain gages. Example: Dimensions on component drawings. Work to be gaged:

Hole	1.250+0.004=1.254 max.
	− .000=1.250 min.
Shaft	1.248+ .000=1.248 max.
	− .004=1.244 min.

Dimensions, Tolerances, and Limits for Gages

GAGES FOR HOLE

Type of gage	Limiting dimensions of part	Gage tolerances	Gage limits
Maximum gages:			
Limit master	1.254	−0.0000 − .0003	1.2540 1.2537
Inspection	1.254	− .0004 − .0007	1.2536 1.2533
Working	1.254	− .0007 − .0011	1.2533 1.2529
Minimum gages:			
Limit master	1.250	+ .0000 + .0003	1.2500 1.2503
Inspection	1.250	+ .0004 + .0007	1.2504 1.2507
Working	1.250	+ .0007 + .0011	1.2507 1.2511

GAGES FOR SHAFT

Type of gage	Limiting dimensions of part	Gage tolerances	Gage limits
Maximum gages:			
Limit master	1.248	−0.0000 − .0003	1.2480 1.2477
Inspection	1.248	− .0004 − .0007	1.2476 1.2473
Working	1.248	− .0007 − .0011	1.2473 1.2469
Minimum gages:			
Limit master	1.244	+ .0000 + .0003	1.2440 1.2443
Inspection	1.244	+ .0004 + .0007	1.2444 1.2447
Working	1.244	+ .0007 + .0011	1.2447 1.2451

By comparison of the above figures, it will be seen that it is not possible for the master, inspection, or working gage dimensions to overlap. This is further illustrated in Fig. 44.

TABLE 30.—Manufacturing Tolerances on Plain Gages

Manufacturing tolerance allowed on work	Allowable tolerance for master gages		Allowable tolerance for inspection gages		Suggested tolerance for working gages	
	Minimum gage	Maximum gage	Minimum gage	Maximum gage	Minimum gage	Maximum gage
Up to 0.0020	+0.0000 + .0001	−0.0000 − .0001	+0.0001 + .0003	−0.0001 − .0003	+0.0003 + .0005	−0.0003 − .0005
0.0021 to 0.0040	+ .0000 + .0002	− .0000 − .0002	+ .0002 + .0004	− .0002 − .0004	+ .0004 + .0007	− .0004 − .0007
0.0041 to 0.0060	+ .0000 + .0003	− .0000 − .0003	+ .0004 + .0007	− .0004 − .0007	+ .0007 + .0011	− .0007 − .0011
0.0061 to 0.0100	+ .0000 + .0004	− .0000 − .0004	+ .0006 + .0010	− .0006 − .0010	+ .0010 + .0015	− .0010 − .0015
0.0101 to 0.0200	+ .0000 + .0005	− .0000 − .0005	+ .0010 + .0015	− .0010 − .0015	+ .0015 + .0021	− .0015 − .0021
0.0201 to 0.0500	+ .0000 + .0006	− .0000 − .0006	+ .0020 + .0026	− .0020 − .0026	+ .0026 + .0033	− .0026 − .0033

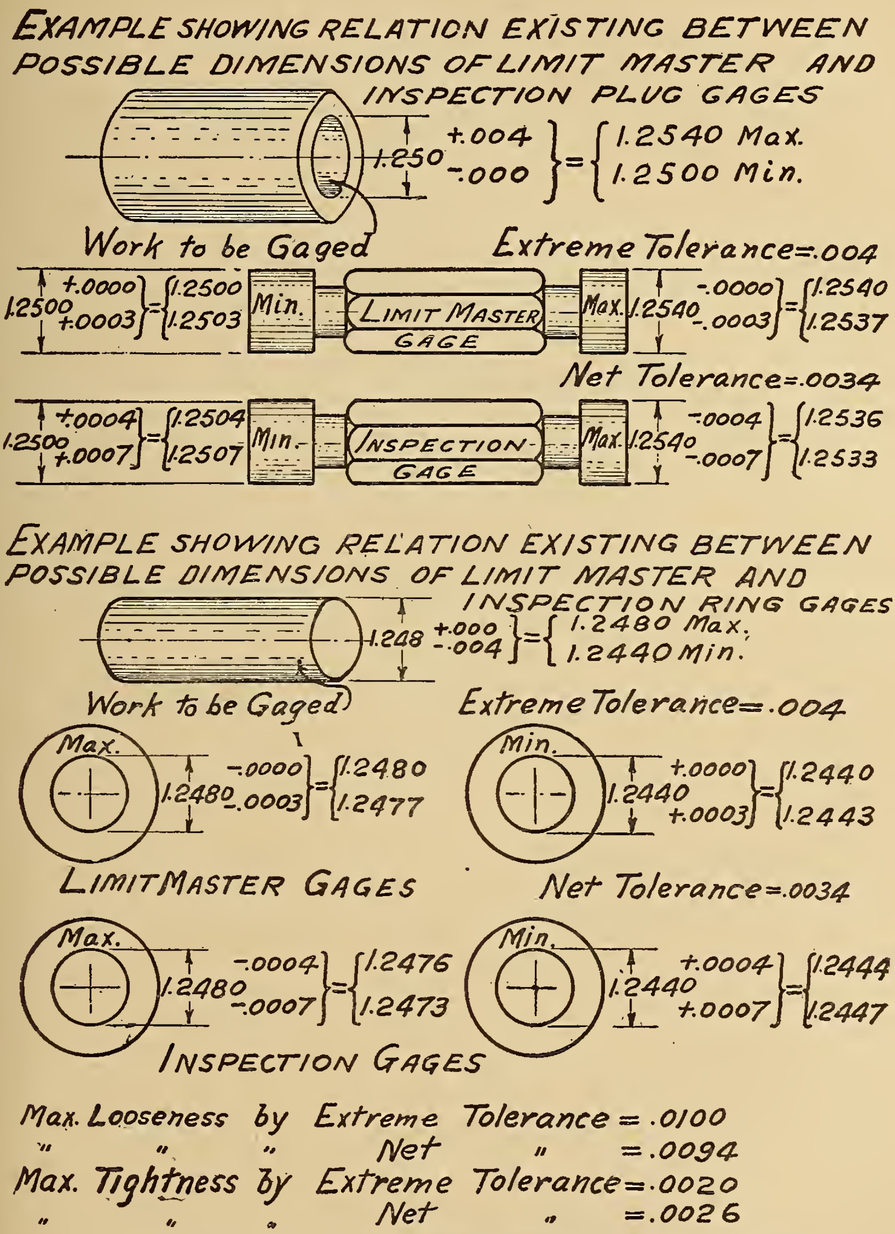


FIG. 44.—*Illustration of relation between dimensions of work and gages*

TABLE 31.—Tolerances on Master Thread Gages for Loose-Fit and Medium-Fit Work (This applies to both standard and limit master gages)

Threads per inch	Allowable variation in lead between any two threads not farther apart than length of engagement	Allowable variation in one-half angle of thread gages	Allowable tolerances on diameters of minimum thread gages	Allowable tolerances on diameters of maximum thread gages
4 to 6	±0.0005	±0° 5′	+0.0000 + .0006	−0.0000 − .0006
7 to 10	± .0004	±0° 5′	+ .0000 + .0004	− .0000 − .0004
11 to 18	± .0003	±0° 10′	+ .0000 + .0004	− .0000 − .0004
20 to 28	± .0002	±0° 15′	+ .0000 + .0003	− .0000 − .0003
30 to 40	± .0002	±0° 20′	+ .0000 + .0002	− .0000 − .0002
44 to 80	± .0002	±0° 30′	+ .0000 + .0002	− .0000 − .0002

TABLE 32.—Suggested Manufacturing Tolerances for Inspection Gages for Loose-Fit and Medium-Fit Work

Threads per inch	Allowable variation in lead between any two threads not farther apart than length of engagement	Allowable variation in one-half angle of thread gages	Allowable tolerances on diameters of minimum thread gages	Allowable tolerances on diameters of maximum thread gages
4 to 6	±0.0006	±0° 5′	+0.0006 + .0015	− 0.006 − .0015
7 to 10	± .0005	±0° 10′	+ .0004 + .0010	− .0004 − .0010
11 to 18	± .0004	±0° 15′	+ .0004 + .0008	− .0004 − .0008
20 to 28	± .0003	±0° 20′	+ .0003 + .0006	− .0003 − .0006
30 to 40	± .0002	±0° 30′	+ .0002 + .0005	− .0002 − .0005
44 to 80	± .0002	±0° 45′	+ .0002 + .0004	− .0002 − .0004

TABLE 33.—Suggested Manufacturing Tolerances for Working Gages for Loose-Fit and Medium-Fit Work

Threads per inch	Allowable variation in lead between any two threads not farther apart than length of engagement	Allowable variation in one-half angle of thread gages	Allowable tolerances on diameters of minimum thread gages	Allowable tolerances on diameters of maximum thread gages
4 to 6	±0.0006	±0° 5′	+0.0015 + .0025	−0.0015 − .0025
7 to 10	± .0005	±0° 10′	+ .0010 + .0020	− .0010 − .0020
11 to 18	± .0004	±0° 15′	+ .0008 + .0015	− .0008 − .0015
20 to 28	± .0003	±0° 20′	+ .0006 + .0012	− .0006 − .0012
30 to 40	± .0002	±0° 30′	+ .0005 + .0010	− .0005 − .0010
44 to 80	± .0002	±0° 45′	+ .0004 + .0006	− .0004 − .0006

TABLE 34.—Master Gage Tolerances for Class III, Close-Fit Work (This applies to both standard and limit master gages)

Threads per inch	Allowable variation in lead between any two threads not farther apa:t than length of engagement	Allowable variation in one-half angle of thread gages	Allowable tolerances on diameters of minimum thread gages	Allowable tolerances on diameters of maximum thread gages
4 to 6	±0.00025	± 2′ 30″	+0.0000 + .0003	−0.0000 − .0003
7 to 10	± .0002	± 2′ 30″	+ .0000 + .0002	− .0000 − .0002
11 to 18	± .00015	± 5′ 00″	+ .0000 + .0002	− .0000 − .0002
20 to 28	± .0001	± 7′ 30″	+ .0000 + .00015	− .0000 − .00015
30 to 40	± .0001	±10′ 00″	+ .0000 + .0001	− .0000 − .0001
44 to 80	± .0001	±15′ 00″	+ .0000 + .0001	− .0000 − .0001

APPENDIX 7. TYPICAL SPECIFICATIONS FOR SCREW-THREAD PRODUCTS

(*a*) MATERIAL.—The material used shall be cold-drawn Bessemer steel automatic screw stock.

(*b*) COMPOSITION—

Carbon, 0.08 to 0.16 per cent,
Manganese, 0.50 to 0.80 per cent,
Phosphorus, 0.09 to 0.13 per cent,
Sulphur, 0.075 to 0.13 per cent.

(*c*) Method of Manufacture.—Bolts and nuts may be either rolled, milled, or machine cut, so long as they meet the specifications herein provided.

(*d*) Workmanship.—All bolts and nuts must be of good workmanship and free from all defects which may affect their serviceability.

(*e*) Finish.—All bolts and nuts to be semifinished; that is, the bodies to be machined, underside of head and nut faced, upper face of head and nut to be chamfered at an angle of 30°, leaving a circle equal in diameter to the width of the nut.

(*f*) Form of Thread.—The form of thread shall be the National Form, as specified in Section III herein, and formerly known as the United States Standard or Sellers Thread.

(*g*) Thread Series.—The pitches and diameters shall be as specified in Table 1, Section IV, herein, and known as the National Coarse-Thread Series.

(*h*) Class of Fit.—Class II–A, Medium Fit (Regular).

(*i*) Dimensions—

(1) Nominal size: ½ inch.

(2) Number of threads per inch: 13.

(3) Length under head: 3 inches ±0.05″.

(4) Minimum length of usable thread: 1 inch.

(5) Diameters: See Table 11, Section V.

(*j*) Tolerances and Allowances.—See Table 10, Section V.

(*k*) Nuts—

(1) Form: Hexagonal.

(2) Thickness: ½ inch ±0.01″.

(3) Short diameter (across flats): ⅞ inch $\begin{cases} +0.000''. \\ -\ \ .005''. \end{cases}$

(*l*) Heads—

(1) Form: Hexagonal.

(2) Thickness: $\frac{7}{16}$ inch ±0.01″.

(3) Short diameter (across flats): ⅞ inch $\begin{cases} +0.000''. \\ -\ \ .005''. \end{cases}$

(*m*) Gages.—The gages used shall be such as to insure that the product falls within the tolerances as specified herein for Class II, Medium Fit (Regular).

The following gages are suggested and will be used by the purchaser:

For the screw—

(1) A maximum or "Go" ring thread gage.

(2) A minimum or "Not Go" ring thread gage to check only the pitch diameter of the thread.

(3) A maximum or "Go" plain ring to check the major diameter of the thread.

(4) A minimum or "Not Go" snap gage to check the major diameter of the thread.

For the nut—

(1) A minimum "Go" thread plug gage.

(2) A maximum or "Not Go" thread plug gage to check only the pitch diameter.

(3) A "Go" plain plug gage to check the minor diameter.

(4) A "Not Go" plain plug gage to check the minor diameter of the thread.

(*n*) Inspection and Test.—Screws and nuts shall be inspected and tested as follows:

At least three bolts and nuts shall be taken at random from each lot of 100, or fraction thereof, and carefully tested. If the errors in dimensions of the screws or nuts tested exceed the tolerance specified for this class, the lot represented by these samples shall be rejected.

(*o*) Delivery.—Unless otherwise specified the assembled bolts and nuts are to be delivered in substantial wooden containers, properly marked, and each containing 100 pounds.

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